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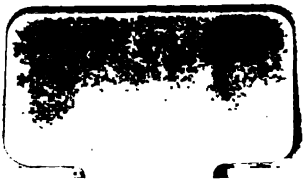
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THIRD SESSION, FORTY-SECOND CONGRESS.

EXECUTIVE DOCUMENTS

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THE HOUSE OF REPRESENTATIVES.

1872-'73.

IN TWELVE VOLUMES.

Volume 1....No. 1, part 1, Foreign Relations, parts 1, 2, 3, 4, 5, and 6.
Volume 2....No. 1, part 2, War, parts 1 and 2.
Volume 3....No. 1, part 5, Interior, parts 1 and 2.
Volume 4....No. 1, parts 3, 4, 6, and 7, and No. 2.
Volume 5....No. 3 to No. 19, inclusive, except No. 5.
Volume 6....No. 5 and No. 190, with which is bound Mis. Doc. No. 44.
Volume 7....No. 20 to No. 91, inclusive.
Volume 8....No. 92 to No. 150, inclusive.
Volume 9....No. 151 to No. 210, inclusive, except Nos. 160 and 190.
Volume 10....No. 160, Commercial Relations.
Volume 11....No. 211 to No. 242, inclusive, except No. 240.
Volume 12....No. 240, Coast Survey.

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TO

THE EXECUTIVE DOCUMENTS

OF THE

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FOR THE

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42D CONGRESS, 3d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, Part 2.

REPORT

OF

THE SECRETARY OF WAR,

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE THIRD SESSION OF THE FORTY-SECOND CONGRESS.

VOLUME II.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1872.

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REPORT

OF

THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 19, 1872.

SIR: I have the honor to present for your information the following report upon the duties and operations of the Engineer Department for the fiscal year ending June 30, 1872:

OFFICERS OF THE CORPS OF ENGINEERS.

The number of officers holding commissions in the Corps of Engineers, United States Army, at the end of the fiscal year, was 103 on the active list and 7 on the retired list; the latter, however, under the law of January 21, 1870, not being available for duty. In the duties devolving upon the corps by law, and its organization, the employment of a number of scientists and civil assistants has been necessary.

Since my last report the corps has lost by death, retirement, and resignation, three officers, namely: Major Nicolas Bowen, died July 11, 1871; Major Frederick E. Prime, retired September 5, 1871, and Major Junius B. Wheeler, resigned October 10, 1871, to accept the position of professor of military and civil engineering at the Military Academy. There have been gained by transfer under the provisions of the act of June 10, 1872, six lieutenants.

On the 30th of June, 1872, the officers were distributed as follows:

On duty, office of the Chief of Engineers, including the Chief	4
On duty, projection and construction of fortifications	7
On duty, construction of fortifications and light-house duty	2
On duty, construction of fortifications and river and harbor works, and surveys for same	21
On duty, construction of river and harbor works and surveys for same	18
On duty, construction of river and harbor works and light-house duty, and surveys for same	6
On duty, survey of northern and northwestern lakes	6
On duty, explorations of country west of Rocky Mountains	3
On duty with battalion of Engineers	13
On duty public buildings and grounds, District of Columbia	1
Off duty, sick	3
Detached, on duty with generals commanding divisions, departments; Light-House establishment; Military Academy; and survey of northern boundary-line under State Department	19
Total	103

The officers detached were on duty as follows:

Colonel I. C. Woodruff, engineer third and fourth light-house districts	1
Major George H. Elliot, engineer-secretary to the Light-House Board	1
Major J. W. Barlow, on staff of Lieutenant-General commanding Military Division of the Missouri	1
Major P. C. Hains, engineer fifth and sixth light-house districts	1

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Major F. U. Farquhar, on duty under Department of State upon the joint commission for the survey and demarkation of the boundary-line along the forty-ninth parallel, in accordance with act of Congress approved March 19, 1872	1
Captain William J. Twining, on duty under Department of State upon the joint commission for the survey and demarkation of the boundary-line along the forty-ninth parallel, in accordance with act of Congress, approved March 19, 1872	1
Captain G. J. Lydecker, on staff of major-general commanding Military Division of the Pacific	1
Captain D. P. Heap, on staff of commanding general Department of Dakota	1
Captain W. A. Jones, on staff of commanding general Department of the Platte	1
First Lieutenant J. F. Gregory, on duty under Department of State upon the joint commission for the survey of the boundary-line along the forty-ninth parallel, in accordance with act of Congress, approved March 19, 1872	1
First Lieutenant J. H. Weeden, on duty under Department of State upon the joint commission for the survey of the boundary-line along the forty-ninth parallel, in accordance with act of Congress, approved March 19, 1872	1
First Lieutenant Ernest H. Ruffner, on staff of commanding general Department of the Missouri	1
Second Lieutenant F. V. Greene, on duty under Department of State upon the joint commission for the survey of the boundary-line along the forty-ninth parallel, in accordance with act of Congress, approved March 19, 1872	1
Second Lieutenant Carl F. Palfrey, on duty under Department of State upon the joint commission for the survey of the boundary-line along the forty-ninth parallel, in accordance with act of Congress, approved March 19, 1872	1
First Lieutenant A. H. Payson, First Lieutenant E. W. Bass, First Lieutenant S. E. Tillman, Second Lieutenant P. M. Price, jr., and Second Lieutenant E. S. Holden, on duty at the Military Academy	5
Total	19

The following principal civil engineers and geologists were employed on the 30th of June:

General J. H. Wilson, member of board of engineers upon improvement of the Des Moines and Rock Island Rapids, and improvement of the Illinois River; and Clarence King, geologist in charge of geological exploration of the fortieth parallel.

Upon application, under the provisions of the act of June 10, 1872, transfer to the Corps of Engineers was made of all graduates of the Military Academy since March, 1869, that had been recommended to the President, by the academic board, for promotion in the Corps of Engineers.

SEA-COAST AND LAKE FRONTIER DEFENSES.

The leading object of this Department, in its operations upon the works of defense, has been to push forward as speedily as possible the modification of the old earthen barbette-batteries, and the construction of new and approved projects for earthen batteries, made in accordance with the system of sea-coast defense adopted since the recent war. The principles to govern in the construction of our defensive works, have been fully stated in my reports for two or three years past, and need not be repeated. They have met with the approval of the General of the Army, and the Executive, and need only to be completed, to give our harbors protection against even the most recently constructed and powerful iron-clad vessels of the maritime powers. Among the appliances for this defense, it will be remembered, are channel-obstructions and systems of torpedoes, but these are accessories, and must themselves be covered by the fire of guns in position, that command the channels. It becomes, then, of primary importance that the guns should be so mounted as to be as secure as it is practicable to make them from destruction by the enemy's fire, delivered from iron-clad vessels of great strength and resistance. The most complete protection would evidently

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be gained by placing the guns in casemate, in which, security is furnished from projectiles coming from the front, the flanks, and overhead; but as yet, within the limits of reasonable cost, we have not devised a structure of this character. By the use, however, of high sand parapets, behind which the gun when fired shall descend, and by covering these guns on either side with high traverses, a combination is obtained which is at once secure from direct and slightly curved fire, whether from the front or flank, and substitutes sand, a cheap material, for the costly iron shields and turrets.

It is absolutely essential, however, that a carriage that shall lower the gun below the parapet be provided, in order to secure these benefits, and accordingly the use of such a carriage was approved as among the principles or rules to govern the construction of our works of defense. Efforts to secure such a carriage have therefore been continued.

The progress upon the defenses of our harbors during the past year has been in every respect satisfactory; the officers and assistants in immediate charge applying themselves with diligence and zeal to the prosecution of the works.

In accordance with my request of July 29, 1871, a board of three ordnance, three artillery, and one engineer officer was ordered to meet and test King's counterpoise gun-carriage, mounted for that purpose in Battery Hudson, Staten Island. The board concluded its trials in December of 1871, and forwarded its report in January of 1872. The record of the firing, and performance of the carriage shows, that the carriage will answer the purpose for which it was devised.

Trials with torpedoes, at the school at Willet's Point, have progressed with very marked success. The investigations have gone so far as to enable us to pronounce upon the special system we will use, and arrange the details of the parts, as well as the methods of handling and operating the torpedoes, and the time has now arrived when we should begin the collection and storage in depots of the materials and mechanism needed for this service. The total cost of the application of this powerful auxiliary to the defense of our coast will be about $2,000,000. An estimate is herewith submitted of $500,000 for the torpedo-defense of some of the more important harbors.

The progress made and anticipated upon the several works along the coast is set forth in detail in the following portions of this report. The estimates submitted have been carefully revised, and are for the completion, continuance, or commencement of projects, and in accordance with the rules for our defensive works heretofore mentioned.

FORTIFICATIONS.

Fort Wayne, Detroit, Michigan, in charge of Major G. L. Gillespie, Corps of Engineers. — This work commands the channel of Detroit River, and, with its exterior barbette-batteries, will control the navigation of that stream. These batteries, not yet completed, should be finished, and additional batteries projected.

No appropriation was made for the fiscal year ending June 30, 1873.

No appropriation asked for the next fiscal year.

The only work performed during the past year has been done for the care and preservation of the work.

Fort Porter, Black Rock, near Buffalo, New York, in charge of Major F. Harwood, Corps of Engineers.—This work occupies an important strategic point for the defense of the northern frontier. During the past year no work was done.

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No appropriation was made for the year ending June 30, 1873.

No appropriation asked for the next fiscal year.

Fort Niagara, mouth of Niagara River, New York, in charge of Major John M. Wilson, Corps of Engineers.—This work is situated at the mouth of the Niagara River, commanding its debouch into Lake Ontario. During the past year the force upon the work has been engaged in repairing and pointing scarp-wall; constructing sewer and drains in main ditch; grading and seeding ditch; paving postern-road, and setting pintle and traverse stones and irons; paving casemates; repairing sea-wall; constructing slope-wall protection for salient angle of north bastion; repairing old crib-work protection at westerly angle of fort; and building new, and repairing breaks, in parapet, and counterscarp.

Appropriation asked for next fiscal year, $25,000.

During the present fiscal year it is proposed to complete the crib-work protection at the westerly angle of the fort, and rebuild the jettees on lake-front, necessary for the preservation of the site of the work.

Fort Ontario, mouth of Oswego River, New York, in charge of Major John M. Wilson, Corps of Engineers.—This work protects the city from a sudden attack or *coup de main*, or the levy of a contribution by a small force of the enemy on shipboard. The work in progress upon the fort is the replacing of the olden timber scarp by more durable materials, and the modification of the barbette for the heavy modern ordnance.

Appropriation asked for the next fiscal year, $30,000.

During the past year the force upon this work has been engaged completing the gallery in right flank of bastion E; continuing the gallery in left flank of bastion A; building the connection of gallery in bastion D to proposed magazine; and forming and sodding parapet on fronts Nos. 5 and 3.

During the coming year it is proposed to complete the galleries in bastion A, and the parapet to the right re-entering angle of that bastion; and to construct the gallery in the right flank of bastion C, and the parapet to the salient of that bastion.

Fort Montgomery, outlet of Lake Champlain, New York, in charge of Lieutenant-Colonel John Newton, Corps of Engineers.—This work occupies an important strategic point, and commands the entrance to Lake Champlain from Richelieu or Saint John River. During the past year no work has been done except slight repairs to magazines, retaining-walls, and general care of the work.

No appropriation was made for the fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $28,000.

Projects for the modification of the work to suit its armament to modern guns have been prepared by the board of engineers for fortifications, and should be carried out.

Fort Knox, Bucksport, Penobscot River, Maine, in charge of Lieutenant-Colonel J. C. Duane, Corps of Engineers.—This work, situated at the narrows of the Penobscot River, furnishes a defense for the city of Bangor and other towns bordering the Penobscot, and renders the river available as a secure harbor of refuge for the shipping of the extensive eastern sea-coast. The work is essentially completed, with the exception of some modifications in its barbette-batteries to fit them for the large guns now used.

No appropriation was made for the fiscal year ending June 30, 1873.

No appropriation asked for the next fiscal year.

The condition of this work remains the same as at the close of the

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last fiscal year. No operations, excepting the necessary care of the work, have been carried on.

Fort Popham, mouth of Kennebec River, Maine, in charge of Lieutenant-Colonel J. C. Duane, Corps of Engineers.—This work defends the entrance, through the mouth of the Kennebec River, to the rich valley of this river, the cities of Bath and Augusta, and the United States arsenal at the latter place. It has been finished upon its gun-fronts to the level of the barbette-batteries. The projects for its completion have been prepared, and are now under consideration.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for the next fiscal year.

The condition of the work remains the same as at the close of the last fiscal year. No operations, excepting the necessary care of the work, have been carried on.

Fort Gorges, Portland Harbor, Maine, in charge of Lieutenant-Colonel J. C. Duane, Corps of Engineers.—During the past year the earth-work of the gorge has been entirely completed, and that of front I very nearly completed. The embankment for the parados, and coverings of bomb-proofs, on the southerly and western fronts, was begun in June. This is expected to be nearly completed by the end of the next fiscal year. The last three positions are now ready for their platforms.

Amount appropriated for fiscal year ending June 30, 1873, $20,000.

No appropriation asked for next fiscal year.

During the present year it is proposed to complete the earth-work of the parados on fronts II, III, IV, and V, and the sodding of one-half of the same, and to finish the stairways and magazines.

Fort Preble, Portland Harbor, Maine, in charge of Lieutenant-Colonel J. C. Duane, Corps of Engineers.—During the past year the great magazine and the easterly traverse-magazine, with their communications, were built in the old redoubt. The embankments upon the same were built, and all their slopes, together with all those of the traverse and parapet, at the junction of this redoubt and the north battery, were sodded and finished. The breast-height wall of the easterly section of the old redoubt was built. In the south battery, the second new traverse-magazine was built, but not graded; about one-half of the parapet-embankment built, and the first two sections made ready for sodding. During the present year it is expected to entirely finish the old redoubt, ready for the last three new gun-platforms. The south battery will be made ready for all its gun-platforms, and the first three sections finished.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $80,000.

Fort Scammel, Portland Harbor, Maine, in charge of Lieutenant-Colonel J. C. Duane, Corps of Engineers.—This work, commanding four of the channels leading into the harbor, occupies a very important position. The stone piers in the parade of the west bastion have been built. In the old fort two-thirds of the parados on front I, and the whole of that on front IV, have been built, and their earth embankments made ready for sodding. The communications through the traverses of front IV, and the rock-excavation for the great magazine, have been completed, and the concrete floor and drains under the latter laid. In the old fort, during the present year, it is expected to complete the great magazine with its earth covering; to finish about one-third of the slopes; to make most of the gun-positions ready for their platforms; and, in the west bastion, to put on the concrete covering.

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Amount appropriated for fiscal year ending June 30, 1873, $42
Appropriation asked for next fiscal year, $100,000.

Battery on Portland Head, Portland Harbor, Maine, in charge o tenant-Colonel J. C. Duane, Corps of Engineers.—Further than t pletion of the projects and making-drawings for this work, no v construction has yet been done. As soon as the title to the la be perfected, the work will be commenced.

Amount appropriated for fiscal year ending June 30, 1873, $5
No appropriation asked for next fiscal year.

Fort McClary, Portsmouth Harbor, Kittery Point, Maine, in ch Lieutenant-Colonel J. C. Duane, Corps of Engineers.—This work, t with Fort Constitution, opposite, forms the only defense to the of the Piscataqua River, and to the navy-yard at Kittery, Maine

No appropriation was made for fiscal year ending June 30, 18
No appropriation asked for the next fiscal year.

The condition of this work remains the same as at the close last fiscal year. No operations, excepting the necessary care of th have been carried on.

Fort Constitution, Portsmouth Harbor, New Hampshire, in ch Lieutenant-Colonel J. C. Duane, Corps of Engineers.—This is a ca work, and the Engineer Department is not prepared, at present ceed with its construction.

No appropriation was made for the fiscal year ending June 3
No appropriation asked for the next fiscal year.

The condition of this work remains the same as at the clos last fiscal year. No operations, excepting the necessary car work, have been carried on.

A plan, prepared by the board of engineers, for the constru an earthen barbette-battery for fourteen guns, in rear of the p casemated work, at an estimated cost of $83,500, was approved honorable Secretary of War, May 21, 1872.

Appropriation asked for next fiscal year, $50,000.

Batteries in Portsmouth Harbor, New Hampshire, in charge of ant-Colonel J. C. Duane, Corps of Engineers.—A project for the i defense of this important harbor was prepared by the board of e for fortifications, and was approved by the honorable Secre War on the 21st of May, 1872. It provides for the construct twelve-gun barbette-battery of sand at Gerrish's Island, Main estimated cost of $45,240.

No appropriation has been made as yet for this work.

Appropriation asked for next fiscal year, $25,000.

Batteries in Portsmouth Harbor, New Hampshire, in charge of ant-Colonel J. C. Duane, Corps of Engineers.—A project prepare board of engineers for fortifications, providing for the constru a twelve-gun barbette-battery of sand at Jerry's Point, at an e cost of $46,824, has been approved by the honorable Secretary

No appropriation has been made as yet for this work.

Appropriation asked for next fiscal year, $25,000.

Fort Warren, Boston Harbor, Massachusetts, in charge of Colo W. Benham, Corps of Engineers.—This important work is for the of the main channel of entrance to Boston Harbor and comma anchorage of Nantasket Roads. In bastion A the removal of th wall has been completed; the piers of all the arches have be and the full center arch and the arch over passage-way to ri casemate have been completed and covered with concrete. T faces of the arch at the gorge, and of arch over stairway at th

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this, have been completed. The remaining arches in the bastion, and the wing and sustaining wall on the right of the gorge, have been partially constructed. In the demi-lune the masonry of the parados has been completed, and the embankment or earth cover of the traverses and parados about completed up to the top of the concrete masonry, and partially sodded; and the sustaining-wall of the gun-platform on the left, with the foundation of that platform and of the breast-height wall in front, is laid.

Amount appropriated for fiscal year ending June 30, 1873, $85,000.

Appropriation asked for next fiscal year, $100,000.

During the present year it is proposed to complete bastion A, the demi-lune battery, and the additional traverse-magazine, and to commence work upon the four-gun battery upon the cover-face of front No. II.

Battery at Long Island Head, Boston Harbor, Massachusetts, in charge of Colonel Henry W. Benham, Corps of Engineers.—This important work is especially intended to command the entrance into Boston Harbor through Broad Sound. During the past year operations have been mainly directed toward the erection of the buildings necessary for the work, such as quarters, shops, store-houses, &c.; the construction of an oak-pile wharf, and a railway of 1,000 feet to the summit of the bluff, and the excavation for the eastern mortar-battery and the parados in rear of it; the commencement of the concrete masonry of these positions, and the construction of the drains in rear of them.

No appropriation was made for the fiscal year ending June 30, 1873.

No appropriation asked for the next fiscal year.

Fort Winthrop, Boston Harbor, Massachusetts, in charge of Colonel Henry W. Benham, Corps of Engineers.—In the east battery four of the seven traverse-magazines, the remaining three being finished except their earth cover and sodding. Two of the three new center-pintle platforms were finished, except as to irons, one partially finished, and some progress made with the four front-pintle platforms. The breast-height wall of this battery is completed except for the four depressible-gun positions, and about half of the new sand parapet is essentially completed. In the south battery during the year the breast-height wall for four gun-positions has been built. At the mortar-battery the most western magazine and shell-room, and the pit for mortar-beds next to the west was completed, or fully one-third of this battery. With the funds available it is expected that during the present year the east battery will be completed, as also the masonry of the breast-height walls and the new gun-platforms of the unfinished portion of the south battery. The concrete arches of the four traverse-magazines of the south battery not yet commenced will probably be completed, and some progress made with the new sand parapet of this battery, and the screened earth cover of its magazines.

Amount appropriated for fiscal year ending June 30, 1873, $64,000.

Appropriation asked for next fiscal year, $63,000.

Fort Independence, Boston Harbor, Massachusetts, in charge of Colonel Henry W. Benham, Corps of Engineers.—During the year there were completed the breast-height walls of the east, the southeast, and the north bastions of the enciente; and the six center-pintle 15-inch-gun platforms of these three bastions, and the breast-height walls of the northwest bastion, and curtain of front I, were commenced. The masonry of the traverse-magazine on the left flank of the north bastion was completed and partially covered with earth. The remaining center-pintle platforms of the barbette-battery of the enciente are at their sites ready

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to be set. The excavations for the sand parapet of fronts I and II, and the completion of the earth cover of the magazines and gun-positions of these fronts, as also the necessary repairing walls, have been partly completed. During the present fiscal year it is contemplated to complete the masonry of the remaining three center-pintle platforms and the six front-pintle platforms of the enciente, as also the three traverse-magazines, the new sand parapets of fronts I and II, and the earth slopes covering the magazines and the gun-positions, thus completing, as far as the present orders authorize, the barbette-battery of the enciente of this work.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $35,000.

Fort at Clark's Point, New Bedford Harbor, Massachusetts, in charge of Major G. K. Warren, Corps of Engineers.—Nothing has been done at this work during the past year, and it has been under the charge of a fort-keeper. The board of engineers has recommended an earthen barbette-battery for twenty-six heavy rifled or smooth-bore guns.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $50,000.

Fort Phœnix, New Bedford Harbor, Massachusetts, in charge of Major G. K. Warren, Corps of Engineers.—Nothing has been done at this work during the past fiscal year, and no expenditures were made there for any purpose. The buildings and property there are of little value, and were looked after by the ordnance-sergeant.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Adams, Newport Harbor, Rhode Island, in charge of Major G. K. Warren, Corps of Engineers.—During the past fiscal year the work performed consisted mainly in making preparations for resuming work on the new batteries by putting the wharves and roads in good order, opening new communications about the work, and repairing those leading from the southeast front to the artillery-stables. The facing of the embrasures on the water-fronts was also completed. The special enumeration of the work is as follows: Completing the new road around the northeast salient; raising the arch of the sally-port on north front, and grading the roadway for carriages, and paving it; repairing wharf at artillery-stable, and the approaches to the wharf on north front; preparing place for coal-yard out of the way of the wharves; repairing and regrading the passage-way out of the southeast front; reconstructing drain in front of the horn-work; completing the refacing of the embrasures on the north and east fronts.

The modification of the new batteries to admit the depressing gun-carriage had not been made in time for operation before the 30th of June.

Amount appropriated for fiscal year ending June 30, 1873, $85,000.

Appropriation asked for next fiscal year, $140,000.

The work the current year will consist in building a new set of quarters for the commanding officer outside of the fort, and in the construction of the new heavy batteries on the water-front.

The estimates for the fiscal year contemplate a rapid prosecution of the work on the new batteries, the building of some additional quarters, and repairs upon the old ones, which are very dilapidated, and whose use cannot yet be dispensed with.

Dumpling's Battery, Canonicut Island, Rhode Island, in charge of Major G. K. Warren, Corps of Engineers.—Nothing has been done at this site during the past fiscal year. It has been proposed to place here ten

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heavy guns in barbette, but the exact plan has not been fixed by the board of engineers, and a contour survey has been recommended to enable this to be done. This survey should be made as soon as practicable.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $50,000.

Defenses of Dutch Island, western entrance to Narragansett Bay, Rhode Island, in charge of Major G. K. Warren, Corps of Engineers.—These defenses are to consist of three detached batteries, *en barbette*, situated upon the summit of the island, and affording emplacements for thirty-eight 15-inch guns, or equivalent rifles.

The work here during the past fiscal year consisted mainly as follows: During the first two months of the fiscal year, preparations of various kinds were made for commencing the batteries, including the assemblage of material, and necessary repairs. It was soon found that a reconsideration of the details of the general plan of the batteries was advisable, and, consequently, early in September, 1871, active operations were suspended, and the island left in charge of a fort-keeper until spring. During the winter of 1871 and spring of 1872, the plans were reconsidered by the board of engineers for fortifications, and a new plan prepared, which received the approval of the Chief of Engineers. March and April were spent in making preparations, receiving and storing material, &c., and early in May ground was broken for foundations of the three service-magazines at the southwest salient of the larger of the three batteries. At the close of the fiscal year the following had been accomplished: Completing the foundations of two service-magazines, and building and setting forms and centers for side walls and arches of same; partly completing foundations for a third magazine, and the forms and centers for its superstructure, and excavating the foundations for a fourth magazine, besides many matters of detail connected with the general conduct of the work and the care of public property.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $50,000.

Fort Trumbull, New London Harbor, Connecticut, in charge of Major G. K. Warren, Corps of Engineers.—Nothing has been done at this work during the past fiscal year, and it has been taken care of by the commanding officer of the garrison. It is designed to modify the exterior batteries at this fort, so as to mount twelve heavy guns.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $20,000.

Fort Griswold, New London Harbor, Connecticut, in charge of Major G. K. Warren, Corps of Engineers.—Nothing has been done at this work during the past fiscal year. It is designed to modify existing batteries, so as to mount nine heavy guns.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $20,000.

Fort Hale, New Haven Harbor, Connecticut, in charge of Major G. K. Warren, Corps of Engineers.—This fort having been dismantled, no work has been done during the past fiscal year. A portion of the land occupied was paid for out of the appropriation for purchase of sites for fortifications, the perfect title having been secured. Measures have been taken, though not yet ended, for getting proper title to the remainder that is required here, and it is believed this will be done during the current year.

No appropriation was made for fiscal year ending June 30, 1873.

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No appropriation asked for next fiscal year.

Fort Schuyler, East River, New York, in charge of Major H. L. Abbot, Corps of Engineers.—The reports of former years show the modifications proposed on this important work for the defense of New York City from approach through East River. In brief, these modifications consist of the alterations necessary to adapt the batteries for the service of the heaviest ordnance of the present time.

Amount appropriated for fiscal year ending June 30, 1873, $85,000.

Appropriation asked for next fiscal year, $100,000.

On the main work the modifications of the north front have been continued; three large brick arches, with intermediate communicating arches, one heavy abutment-pier, the greater portion of the new parade-wall, and the new coping to the scarp-wall have been built. The bridge, for the supply of material, is completed across both ditches. On the cover-face the parados in the south bastion, together with the thickening of the magazines and parapet, have been completed. On the place of arms, the parados and parapet have been sodded.

During the present year it is proposed to finish all work in hand on the north front, and to commence the modification of the northeast front.

Fort at Willet's Point, eastern entrance to New York Harbor, in charge of Major H. L. Abbot, Corps of Engineers.—With Fort Schuyler, this work unites in the defense of the entrance to the harbor of New York City, through the East River, and its site is favorable to the construction of earthen barbette-batteries. The operations for the removal of natural obstructions to navigation at Hell Gate render it even more important than heretofore that this channel of approach to New York City and the Brooklyn navy-yard should be put in proper state of defense.

Amount appropriated for fiscal year ending June 30, 1873, $76,500.

Appropriation asked for next fiscal year, $100,000.

During the past year the large storage-magazine, designed to contain 250,000 pounds of powder, has been completed, except part of the earth covering. The drain-pipes and ramps connected with the underground passage-way from the main work to the casemated battery have been finished. The Little Bay battery, (two guns,) and the west battery, (6 guns,) with their five traverse-magazines, have been essentially completed. The excavation for the magazines of the mortar-battery has been made, and about three-fourths of the concrete stone prepared. Extensive repairs have been put upon the wharf.

During the fiscal year ending June 30, 1873, it is proposed to finish the west battery for six guns with its service-magazines, and so much of the middle battery for ten guns as has been commenced; the remainder of the middle battery will be filled in gradually. The east battery for seven guns, with its magazines, will be commenced. All the concrete work in the mortar-battery will be finished during the warm weather, and the earth-work during the winter and spring.

Fort Columbus, Governor's Island, New York Harbor, in charge of Lieutenant-Colonel John Newton, Corps of Engineers.—Six shot-beds have been built, and foundations for eight more excavated, and dry stone and concrete masonry laid. In the new barbette-battery six magazines have been coated with Portland cement on the outside, the parapet has been constructed and completed, and the terreplein has been reduced to the proper level.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $70,000.

Castle William, Governor's Island, New York Harbor, in charge of

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Lieutenant-Colonel John Newton, Corps of Engineers.—Nothing has been done at this work during the past year.

South Battery, Governor's Island, New York Harbor, in charge of Lieutenant-Colonel John Newton, Corps of Engineers.—Nothing has been done at this work during the past year.

Fort Wood, Bedloe's Island, New York Harbor, in charge of Lieutenant-Colonel John Newton, Corps of Engineers.—This work, together with those upon Governor's Island, is designed to close the entrance to the East and Hudson Rivers, and to cover New York, part of Brooklyn, and Jersey City, from the bombardment of a hostile fleet in New York Bay. This work remains the same as at last annual report, but little work having been done. The entrances to the magazines in the exterior water-battery, built last year, have been completed, and portions of the parapet raised to the proper height.

Amount appropriated for fiscal year ending June 30, 1873, $17,000.

Appropriation asked for next fiscal year, $40,000.

Fort Hamilton and additional batteries, New York Harbor, in charge of Lieutenant-Colonel John Newton, Corps of Engineers.—During the past fiscal year the sea-wall of water-battery No. 1 was carried up two courses, and is ready for coping; the rear of the sea-wall has been filled in with earth to a general level of two feet below the top of the sea-wall.

Amount appropriated for fiscal year ending June 30, 1873, $40,000.

Appropriation asked for next fiscal year, $50,000.

Mortar-Battery at Fort Hamilton, New York Harbor, in charge of Lieutenant-Colonel John Newton, Corps of Engineers.—During the past fiscal year, six traverse-magazines, including three service-magazines, have been built and completed, except doors and sodding. The terre-plein and parapet are also completed, except grading and sodding. Funds for this work were derived from general appropriation for mortar-batteries.

Fort on site of Fort Tompkins, New York Harbor, in charge of Major Q. A. Gillmore, Corps of Engineers.—This important work crowns the hill in rear of the open batteries and other works on Staten Island, commands the entrance through the Narrows to New York Harbor, acts as a keep for those works, and, when completed, will throw a heavy fire from a high elevation upon vessels attempting to pass before it. During the past year all the masonry of the two gateways and the two sally-port arches, and the walls and arches of the passage-ways over the sally-ports, were finished. The opening left in the scarp-wall for ingress and egress was closed, and the scarp-wall north and south of the sally-port lowered five feet and the coping relaid. The granite parade-wall was finished except the coping, and the masonry of the four traverse-magazines was carried up to the springing lines of the arches. The walls of the south circular stairway were carried up to the skew-backs, and those of the passage-way to parade to the level of parade-coping. The casemate and sally-port arches were covered with mastic, and with earth filling, sodded on the exterior slope, to 5 feet 6 inches below terreplein. The iron balcony and stairs along the second tier casemates, and along the parade-coping of channel-front, were nine-tenths completed.

During the present year it is proposed to finish the work with the exception of the glazing and interior finish of twenty-five casemates for quarters on the land-fronts, to repair and build necessary roads, and provide gutters, &c., for drainage, and to complete the sodding and grading of the slopes.

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Amount appropriated for fiscal year ending June 30, 1873, $83,000.

Appropriation asked for next fiscal year, $30,000.

Glacis Gun-Battery, (north of Fort Tompkins,) Staten Island, New York Harbor, in charge of Major Q. A. Gillmore, Corps of Engineers.—During the past year this battery was finished with the exception of hanging the magazine-doors and laying the breast-height wall and timber gun-platforms, to do which will consume one month's labor. The disbursements for the work were made from the appropriation for fort on site of Fort Tompkins for the fiscal year ending June 30, 1872.

No appropriation asked for next fiscal year.

Glacis Mortar-Battery, (south of Fort Tompkins,) Staten Island, in charge of Major Q. A. Gillmore, Corps of Engineers.—During the past year this battery was completed with the exception of hanging the magazine-doors and laying the mortar-platforms. As soon as the platforms are creosoted they will be laid, and the battery will then be finished, probably in the early part of the present year.

Battery Hudson, Staten Island, New York Harbor, in charge of Major Q. A. Gillmore, Corps of Engineers.—This work, together with those on the north and south cliffs, forms a system of open earthen barbette-batteries, lying exterior to Forts Tompkins and Wadsworth, and brings a powerful fire to bear upon the channel, up to and through the Narrows.

Amount appropriated for fiscal year ending June 30, 1873, $17,000.

Appropriation asked for next fiscal year, $29,000.

That portion of this battery bearing upon the lower bay was not entirely completed during the last fiscal year, in consequence of the delay in getting the timber gun-platforms creosoted, and the inconvenience of working near King's counterpoise-carriage during the construction of its platform and the experimental firing which followed. The platform and parapet for King's carriage were constructed, the entrance retaining-walls were built, and the earth cover formed, but not sodded, for the two traverse-magazines west of light-house.

In Battery Hudson extension, the principal magazine and the rear slope of battery were sodded; the terreplein was excavated to about the proper grade, and the earth-work of the two traverse-magazines formed but not sodded. The cottage in rear of the extension was removed, and the glacis west of the principal magazine formed to the proper grade. The south face of the battery requires about six weeks' work for its completion, which will be accomplished during the present working season. Important and desirable modifications have been designed and approved for the east face of this battery, bearing across the "Narrows," to fit it for the reception of 15-inch guns, and it is very desirable that these modifications should be executed at an early day.

North Cliff Battery, Staten Island, New York Harbor, in charge of Major Q. A. Gillmore, Corps of Engineers.—During the past year the concrete masonry in the principal magazine and two service-magazines was completed and the walls of the covered passage in solid traverse carried up to springing line; a portion of the earth-work of magazines and traverse formed, and the old breast-height wall and platforms in south end of battery removed. With the exception of the platforms, breast-height wall, and high parapet for the depressing-guns, two months' work will complete the battery.

South Cliff Battery, Staten Island, New York Harbor, in charge of Major Q. A. Gillmore, Corps of Engineers.—As the modification of this battery requires a considerable reduction in the armament of the position, it was not deemed advisable to dismount any of its guns and

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begin work until the gun-platforms were laid in Battery Hudson extension, and on the channel-front of Fort Tompkins, and the glacis gun-battery. The work will be commenced during the present fiscal year.

Fort at Sandy Hook, New Jersey, in charge of Lieutenant-Colonel John Newton, Corps of Engineers.—During the past year, for the protection of the site, two jettees were built of sheet-piling, four inches and six inches thick, driven into the sand; the jettees were constructed in this manner, each 150 feet in length. These jettees answered the purposes for which they were built, the beach having formed to a considerable extent.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieutenant-Colonel J. D. Kurtz, Corps of Engineers.—This work occupies a position upon the inner line of defense of the city of Philadelphia and the naval establishment at League Island. During the past year about 1,700 feet of dikes were reconstructed; a site for a nine-gun battery, south of fort, located; a fence on south boundary erected; unserviceable magazine removed, and sluice, wharf, and public buildings repaired. The masonry for two small service-magazines in the mortar-battery has been carried forward to near completion.

Amount appropriated for fiscal year ending June 30, 1873, $72,000.

No appropriation asked for next fiscal year.

During the present year it is proposed to complete the sand traverses to two service-magazines in demi-lune; construct three gun-platforms on south face; large storage-magazine, and temporary pile-pier and trestle-work for the reception and delivery of material for exterior battery.

Next year it is proposed to construct a dike on south boundary-line; complete the exterior battery for nine guns; rebuild the existing wharf, and make requisite repairs to quarters occupied by Engineer Department.

Fort Delaware, Delaware River, Delaware, in charge of Lieutenant-Colonel J. D. Kurtz, Corps of Engineers.—This work is situated on the Pea-Patch Island, and forms one of the chain of works constituting the outer line of defense for the Delaware River. During the past year nine magazines and traverses on the terreplein of the fort were finished; the terreplein at bastion IV–V was extended, and preparations were made to receive the new platforms for heavy guns. Necessary repairs to the dike, temporary buildings, and bridges were made.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $50,000.

During the present year it is proposed to put down the platforms for 15-inch guns; hang the doors to the magazines, and protect the entrances with storm-sheds; complete the cleansing of the ditches; repair the scarp on front II and the upper eastern wharf, and execute minor repairs of bridges, fences, and roads.

At this work during the past year a series of observations on the force and direction of the surface and sub-surface currents in this vicinity, commenced in the previous year, were completed.

Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieutenant-Colonel J. D. Kurtz, Corps of Engineers.—The jurisdiction of the United States to the site of this battery was perfected in May, 1872, and preparations for active operations were immediately begun. The necessary temporary buildings have been commenced, the dike along the river-front repaired, and measures taken to procure materials for a wharf.

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No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $75,000.

It is proposed during the present fiscal year to complete the temporary buildings and wharf, and to commence the construction of the battery.

New Fort, opposite Fort Delaware, Delaware shore, in charge of Lieutenant-Colonel J. D. Kurtz, Corps of Engineers.—The site for this barbette-battery was acquired by the United States in September, 1871. During the past year the necessary temporary buildings, fences, and roads were nearly completed, and the construction of a wharf was commenced.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $50,000.

It is proposed during the present year to complete the buildings and wharf, construct a permanent dike along the water-front, and commence the construction of the battery.

Fort McHenry, Baltimore Harbor, Maryland, in charge of Major William P. Craighill, Corps of Engineers.—This work forms part of the inner line of defense for Baltimore and its dependent interests, and commands with its fire the interior waters of the harbor and the channels of approach thereto.

A project for a large exterior battery for guns of the largest calibers has been some time prepared, but its construction could not be begun for want of funds. The only work during the past year has been the necessary repairs for the proper preservation of the work.

Amount appropriated for fiscal year ending June 30, 1873, $21,000.

Appropriation asked for next fiscal year, $25,000.

Lazaretto Point, opposite Fort McHenry, Baltimore Harbor, Maryland, in charge of Major William P. Craighill, Corps of Engineers.—An efficient battery for guns of the largest caliber, designed to cross its fire with that of Fort McHenry, and form part of the inner line of defense of the harbor, has been some time prepared for this site, but the battery could not be built for want of funds. It is not considered expedient to commence work now at that point, and it is recommended that the small appropriation of $13,000, made June 10, 1872, for this locality, be transferred to the credit of Fort McHenry, which is distant but a few hundred yards, and belongs to the same line of defense.

No appropriation asked for next fiscal year.

Fort Carroll, Baltimore Harbor, Maryland, in charge of Major William P. Craighill, Corps of Engineers.—This fort is situated upon the outer line for the defense of the harbor of Baltimore. It is a casemated work, and until the best methods of arranging such defense shall have been devised, no expenditures upon it are proposed other than for its preservation.

Obstructions of the Potomac, in charge of Major William P. Craighill, Corps of Engineers.—It has not yet been found practicable to make the desired experiments upon these obstructions. The material has been left in store at Fort Foote.

Fort Foote, Potomac River, Maryland, in charge of Major William P. Craighill, Corps of Engineers.—This work forms the inner line of defense of the channel of approach by water to Alexandria, Washington, and Georgetown. Projects for the modification of this fort, and for an additional battery for the use of the heaviest guns, have been some time prepared. Arrangements have been made for the purchase of the site, and the legislature of Maryland has made cession of jurisdiction. When the title is approved by the proper authority, operations in construction

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may be at once begun with funds appropriated June 10, 1872. Some necessary repairs to the wharf have been made.

Amount appropriated for fiscal year ending June 30, 1873, $21,000.

Appropriation asked for next fiscal year, $25,000.

Fort Washington, Potomac River, Maryland, in charge of Major William P. Craighill, Corps of Engineers.—This fort occupies an important position on the outer line of defense of the cities of Alexandria, Washington, and Georgetown and their dependent interests. The line requires strengthening by the introduction of guns of the heaviest calibers.

Projects of earthen barbette batteries to occupy positions immediately north and south of the main work, as well as plans for the modification of the existing water-battery, have been some time prepared, but their construction could not be begun for want of funds. No expenditures during the year.

Amount appropriated for fiscal year ending June 30, 1873, $21,000.

Appropriation asked for next fiscal year, $25,000.

Fort Monroe, Old Point Comfort, Virginia, in charge of Major William P. Craighill, Corps of Engineers.—This extensive work occupies an important position, covering the approach to Hampton Roads, the navy-yard at Portsmouth, and the James River. Projects have been for some time prepared by the board of engineers for fortifications for the modifications needed to adapt the work for heavy guns of the largest size. Owing to the want of appropriations, the operations for the year have been confined to repairing and rebuilding three 15-inch-gun platforms, and making other necessary repairs, which have been quite extensive. The pintle-stones injured by the experimental firings in 1871 have been removed and others substituted. The two front-pintle 15-inch-gun platforms, Nos. 1 and 3, in the covered-way, have been rebuilt, as has been the bridge at the small postern in the face of the left bastion of front VII. A wooden sustaining-revetment in the rear of the ordnance-office has been renewed. Repairs have been made upon the ramps, terre-plein, casemates, buildings, and bridges, in and about the work.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $100,000.

Artesian Well at Fort Monroe, Virginia, in charge of Major William P. Craighill, Corps of Engineers.—Work on this well was suspended for want of funds in August, 1870, and was resumed about the 1st of October, 1871. It was determined to drill instead of boring, the latter process having ceased to be practicable, in this case, and the work preliminary to this change will soon be completed. The depth will then be increased to about 1,200 feet, at which point the geologists have stated there is a fair prospect of obtaining good water. The present water-supply at the fort is insufficient and expensive, and it is a matter of grave importance to have a supply which will be ample and unfailing, especially in time of war.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Wool, Hampton Roads, Virginia, in charge of Major William P. Craighill, Corps of Engineers.—This casemated work unites with Fort Monroe in closing the passage to Hampton Roads, crossing its fire with the guns from that fort. Until approved projects for its completion are devised, no further work is contemplated other than that necessary to preserve it from injury.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Macon, Beaufort Harbor, North Carolina, in charge of Major Q.

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A. Gillmore, Corps of Engineers.—During the past year operations at this work have been confined to repairs of the wharf, and the construction of a breakwater under the same, the expense incurred being borne by the appropriation for contingencies of fortifications.

During the present year it is proposed to make further repairs, increase the security of the wharf, and also to place sheet-iron chimney-caps on the casemate-chimneys.

No appropriation asked for next fiscal year.

Fort Caswell, mouth of Cape Fear River, North Carolina, in charge of Major Q. A. Gillmore, Corps of Engineers.—This work was erected for the defense of Wilmington City, North Carolina, at a time when it covered the only water-approach to that place. By the subsequent enlargement of New Inlet, however, vessels, can avoid Fort Caswell, and enter Cape Fear River six miles from its mouth. A work at each of these entrances will doubtless be required for a perfect defense, but a single work on Cape Fear River, above their junction, at old Brunswick, about two miles below Orton's Point, will also be necessary, and its construction should take precedence, in point of time, over the works on the outer line.

No work on this fort is proposed until the whole subject of the defense of this position can be carefully revised.

No appropriation asked for next fiscal year.

New Work at Old Brunswick, Cape Fear River, North Carolina, in charge of Major Q. A. Gillmore, Corps of Engineers.—Plans and estimates for works of defense at this point, comprising a line of open batteries, with a tower in rear for their protection and as security against an attack by land, have been prepared, and now await the action of the board of engineers for fortifications. Thirty five thousand dollars will be required for the purchase of site, the erection of barracks, shops, and storehouses, and the commencement of the work.

No appropriation asked for next fiscal year.

Fort Moultrie, Charleston Harbor, South Carolina, in charge of Major Q. A. Gillmore, Corps of Engineers.—The old platforms, the flagging of terreplein, the breast-height parade, and tie-walls, the palmetto crib-traverses on the terrepleins, and the heavy wooden bomb-proofs on the parade and adjacent to the scarp-wall, were removed. The scarp-wall was uncovered completely and repaired, and only awaits the coping to finish it. The old magazine in the northwest angle was uncovered, and the remains of the old brick quarters on the west face taken out. Three service-magazines, in the south, southeast, and southwest faces, respectively, were completed, except the doors, and the foundations and platforms for two 15-inch guns were laid. The bricks from confederate Fort Ripley were transported to Fort Moultrie.

During the present fiscal year it is proposed to finish the work on the channel-bearing fronts, from the curtain of the east face around to the flank of the west face, and perhaps begin the principal magazine in rear of the east face, omitting the platforms, breast-height wall, and high parapet for the depressing-carriages.

Amount appropriated for fiscal year ending June 30, 1873, $35,000.

Appropriation asked for next fiscal year, $50,000.

Fort Sumter, Charleston Harbor, South Carolina, in charge of Major Q. A. Gillmore, Corps of Engineers.—During the past fiscal year the scarp-wall for the east half of the gorge and the entire southeast face was constructed, and only awaits the coping to complete it. The broken arches in rear were removed and the site leveled. The timber and masonry *débris*, which in large amounts occupied the interior of these two faces,

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and the angle between them, was thoroughly excavated, and a surface-magazine constructed on the southeast face, and finished, with the exception of a portion of the gallery and the doors. The casemates of the northeast face were cleared of the sand that filled them, and uncovered on top and in rear. The casemates of the second tier on this face were removed, and the scarp-wall cut down to the level of the top of the recess arches. The middle casemates of the west face were uncovered, the scarp-wall being cut down to reference (18,) and the sites of two 15-inch guns were prepared, and the foundations and platforms put down. Two cisterns, of 2,700 and 3,500 gallons' capacity, respectively, were constructed. Also a temporary building for the storage of tools and cement.

During the present fiscal year it is proposed to construct a service-magazine, complete the covering, and sod the one already partially finished, and build the breast-height and parapet in front of the platforms already in position.

Amount appropriated for fiscal year ending June 30, 1873, $35,000.

Appropriation asked for next fiscal year, $50,000.

Fort Johnson, Charleston Harbor, South Carolina, in charge of Major Q. A. Gillmore, Corps of Engineers.—No operations were carried on at this work during the past fiscal year, and no funds are available at present. An appropriation is required for the execution of the approved project for repairing and maintaining this work as at present designed, comprising the construction of one concrete magazine, and such necessary alterations and enlargements in existing emplacements for guns, as will fit them for the reception of 15-inch smooth bores or corresponding rifles.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $10,500.

Castle Pinckney, Charleston Harbor, South Carolina, in charge of Major Q. A. Gillmore, Corps of Engineers.—No operations have been carried on at this work during the past fiscal year, and there are no available funds at the present time.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $8,500.

Fort Jackson, Savannah River, Georgia, in charge of Major Q. A. Gillmore, Corps of Engineers.—The modification of this work, so as to fit it for the reception of heavy guns, in accordance with the official plan, will be commenced during the present fiscal year. As Fort Pulaski can be avoided by a fleet entering the Savannah River by way of Nassau Sound and Saint Augustine Creek, Fort Jackson furnishes the only direct defense of the city of Savannah against a naval attack. Its completion at an early day is therefore desirable. A new wharf and a new temporary building for men's quarters will have to be constructed.

Amount appropriated for fiscal year ending June 30, 1873, $15,000.

Appropriation asked for next fiscal year, $9,000.

Fort Pulaski, Savannah River, Georgia, in charge of Major Q. A. Gillmore, Corps of Engineers.—Besides the erection of the necessary temporary buildings, such as barracks, stables, store-houses, and workshops, the operations during the past year consisted in the removal of the old gun-platforms and breast-height wall of the demi-lune; the raising of the scarp-wall of both faces 2 feet 6 inches, to reference (11;) the re-arrangement and sodding of the exterior and superior slopes; the excavation of the old terreplein for the piling and grillage for the guns and magazines of the north face, and the center-pintle gun at the salient; the construction of the grillage for the two guns in the northeast angle; driving the piling

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for the adjacent service-magazine; the framing of two flood-gates for the canal, and replacing the draw-bridge over the demi-lune ditch.

During the present fiscal year it is contemplated to carry on the construction of the grillage on the north demi-lune face, and get down the platforms for one or two guns.

During the next fiscal year the execution of the official plan for modifying the main work, so as to fit it for the heavy armament designed for it, should be commenced.

Amount appropriated for fiscal year ending June 30, 1873, $25,000.

Appropriation asked for next fiscal year, $75,000.

New Fort on Tybee Island, mouth of Savannah River, Georgia, in charge of Major Q. A. Gillmore, Corps of Engineers.—Plans and estimates for works of defense on Tybee Island, comprising a line of open batteries, with concrete tower in rear for their protection against assault, have been prepared, and now await the action of the board of engineers for fortifications.

Fort Clinch, Amelia Island, Florida, in charge of Major Q. A. Gillmore, Corps of Engineers.—No operations have been carried on at this work during the past fiscal year, except such slight repairs as could be accomplished by the fort-keeper, and there are no funds available at the present time, except a small sum allotted from the general appropriation for contingencies of fortifications.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Marion, Saint Augustine, Florida, in charge of Major Q. A. Gillmore, Corps of Engineers.—The slight repairs which it was expected would be made at this work, were not undertaken, an inspection of the place, made by the engineer in charge last January, having shown that they were really not necessary for the convenience of the ordnance-sergeant stationed there, and could well await the projects of important operations elsewhere on the coast.

It is contemplated to expend, next autumn and winter, the small sum allotted from the general appropriation for contingencies of fortifications for these repairs, although at least $5,000 would be required to place the masonry of the fort in a sightly condition. The position has no military significance.

Fort Taylor, Key West, Florida, in charge of Lieutenant-Colonel C. E. Blunt, Corps of Engineers.—This work, for the defense of the important harbor of Key West, is still in an unfinished condition. The operations at this work during the past year have been prosecuted in pursuance of the new plans for additional defenses of this important harbor, prepared by the board of engineers and approved by the Chief of Engineers and the honorable Secretary of War. The four main magazines of the fort have been strengthened by thickening the scarp-wall. The barbette-tier has been modified by the removal of eighteen platforms for 10-inch guns, and the substitution therefor of two 15-inch-gun platforms and three sand traverses. The embankments (sand) of the two barbette-batteries close to the beach, north and south of the fort, have been commenced and carried sufficiently far to provide emplacements for six 15-inch guns, (two in the north and four in the south battery.) The case-mate foundations for platforms, and the platforms themselves, have been laid, and the guns can now be mounted. One magazine has been well advanced. Further operations during the coming season will be in continuance of the construction of the exterior batteries.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $75,000.

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Fort Jefferson, Garden Key, Tortugas, Florida, in charge of Lieutenant-Colonel C. E. Blunt, Corps of Engineers.—During the year 283 running feet of the unfinished sea-wall have been raised to low-water mark, a portion of the ditch being previously pumped out and concrete foundations laid. The modifications of the work, which have been approved by the honorable Secretary of War, have been taken in hand. The four curtain-magazines have been strengthened by increasing the thickness of adjacent scarp to 12 feet. Eight of the barbette-magazines have been modified in part. The concrete foundation for platforms and the platforms themselves have been commenced and completed in the bastions, and six 15-inch guns can now be mounted. Three center-pintle (masonry) platforms for 300 pounder Parrot-guns have also been constructed on the terreplein of the curtains. The funds available for next year will be expended in continuing the approved modifications of the work.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $75,000,

Fort Pickens, Pensacola Harbor, Florida, in charge of Colonel J. H. Simpson, Corps of Engineers.—This work is in a fair condition. During the year the doors of the southeast magazine of bastion A, to secure and preserve the ammunition stored therein, have been repaired. A fort-keeper has been in care of the public property. During the next fiscal year it is proposed to mature plans for the modification of the work.

No appropriation was made for the fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Barrancas and Redoubt, Pensacola Harbor, Florida, in charge of Colonel J. H. Simpson, Corps of Engineers.—Nothing has been done during the year, and the work remains in the same condition reported last year.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Morgan, eastern entrance to Mobile Bay, Alabama, in charge of Colonel J. H. Simpson, Corps of Engineers.—The wharf, which had been entirely destroyed by the sea-worm, has been rebuilt, by the substitution of iron screw-piles for the wooden piles which supported the superstructure, and the stone, brick, and wood pier leading to it has also been renewed.

It is proposed for the next fiscal year to construct a sea-wall for the protection of the west or channel-front of the fort, which was ordered last year, but suspended on account of the funds for the purpose having been withdrawn for other objects, and to take general care of the work.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Gaines, Dauphin Island, Mobile Bay, Alabama, in charge of Colonel J. H. Simpson, Corps of Engineers.—This work needs complete modification to fit its emplacements for barbette-guns for the reception of the large modern armaments. During the year repairs have been made to the store-house, and a new bridge, leading over the ditch to the sally-port, has been built. It is proposed, during the next fiscal year, to construct palmetto-pine jettees, designed to preserve the shore and glacis of the channel on the east front, to build a new wharf, and to maintain a general care of the work.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort on Ship Island, coast of Mississippi, in charge of Colonel J. H. Simpson, Corps of Engineers.—This work is in the same condition as

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shown by the last annual report. During the past year operations have been restricted to the care and preservation of the work.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort Pike, Rigolets Pass, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—This work commands the passage by vessels, drawing seven feet or less, through the Rigolets into Lake Pontchartrain, and to the wharves on the lake-front of New Orleans. Projects for its modification, in accordance with the approved system, were prepared and approved in 1870, and detailed estimates of the cost of the proposed modifications made out.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $24,000.

During the past year $2,000 was allotted, from the appropriation for contingencies of fortifications, for repair and preservation of the work, and with which the quarters and magazines were repaired, as also the bridges over the ditches and the breakwater. To provide for the care of the work during the present year there will be allotted $600 from the appropriation for contingencies of fortifications.

Fort Macomb, Chef Menteur Pass, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—This work commands the passage, by vessels drawing four and a half feet or less, through the bayou Chef Menteur into Lake Pontchartrain and the road along Gentilly Ridge to the city of New Orleans. Projects for the modification of this work to fit it for the reception of the latest approved armament were submitted in 1870, and estimates of cost prepared.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $24,000.

During the past year there was allotted, for repairs and preservation of the work, from the general appropriation for contingencies of fortifications, $4,000.

Tower Duprés, Lake Borgne, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—No work was done here during the past year. One thousand dollars allotted for the present fiscal year, from the general appropriation for contingencies of fortifications, will be expended for repair and preservation of the work.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Battery Bienvenue, Lake Borgne, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—For the past fiscal year $1,000 was allotted, from the appropriation for contingencies of fortifications, for the repair of this battery and for rendering it habitable by a fort-keeper, and with this sum the slopes were mowed and repaired, all rubbish removed from the interior of the work, the barracks and officers' quarters put in repair, and a foot-bridge built across the moat.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Tower at Proctorsville, Lake Borgne, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—No work done during the past year. Three hundred and sixty dollars was allotted, from the appropriation for contingencies of fortifications, and expended for pay of a fort-keeper to protect the work and material on hand from depredation. Three hundred and sixty dollars, allotted from the same fund, will be expended for the same purpose during the present year.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

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Fort Jackson, Mississippi River, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—This work and Fort Saint Philip, nearly opposite, are situated on the Mississippi River, about sixty-five miles below New Orleans, and constitute the main defenses of that city against hostile naval expeditions. The depth of water through the bayous and lakes leading toward the city will only permit the approach of the smaller vessels, carrying light armaments. The principal channel-way to the city, through which a naval attack may be made, is the Mississippi River.

Operations during the past year, under an appropriation of $50,000, have consisted in preparations for lodging and subsisting the large force of laborers employed; the collection by purchase of tools, &c., required in the prosecution of the work; the construction of levees and a draining-machine to protect the site of the fort from overflow; the demolition of useless buildings, and thorough police of the fort and inclosure; the clearing and repairing of all grassed slopes; the construction of a railroad to facilitate the transport of materials from the wharf to the lower battery; the grading and construction of drains in the lower battery; the completion of the concrete work for five magazine-traverses in the lower battery, one in battery in lower end of covered way, and in the collection of material requried for construction.

Amount appropriated for fiscal year ending June 30, 1873, $64,000.

Appropriation asked for next fiscal year, $100,000.

During the present year it is proposed to complete the lower battery, the two batteries in the covered way, and emplacements for two guns on the main work; making altogether new emplacements for twenty guns.

A modification of the plan adopted for a new upper battery has been suggested, and referred to the board of engineers for fortifications for consideration.

Fort Saint Philip, Mississippi River, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—Operations during the past year consisted in making the necessary preparations for commencing a new work; quarters were prepared; arrangements made for subsisting on an average one hundred laborers, and a full outfit of tools purchased; entirely rebuilding an important levee and partially rebuilding the wharf; collecting the material required in the constructions projected; building the concrete work of two magazines and partially building three others; constructing the parapet of the new battery; a general police of the old work; making necessary repairs to that portion which is to remain undisturbed, and partially demolishing the portion to be removed.

There is available for the present year an appropriation of $42,500, which, it is estimated, will complete the new battery, making emplacements for twelve guns.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $50,000, which will be applied to the upper and lower batteries.

Fort Livingston, Barataria Bay, Louisiana, in charge of Captain C. W. Howell, Corps of Engineers.—This barbette-work is situated on the western end of Grand Terre Island, at the entrance to Barataria Bay. It guards the only approach to New Orleans, by vessels drawing seven feet or less, available on the west side of the Mississippi River; it also secures a safe anchorage and harbor of refuge for our once light-draught coasters in time of war.

A project for its modification and repair was devised and approved in

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1870. Estimates of the probable cost were prepared at the same time. To carry to completion this approved project there will be required an appropriation of $38,000.

During the past year there was allotted from the appropriation for contingencies of fortifications, to place this work in condition for its preservation, the sum of $2,500.

No appropriation made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Fort at Fort Point, entrance to San Francisco Harbor, California, in charge of Lieutenant-Colonel C. S. Stewart, Corps of Engineers.—This is one of the principal works for the defense of the entrance to the harbor of San Francisco through the Golden Gate, the approaches to this entrance, and the inner waters of this passage. It is situated on the southern side of the channel, and consists essentially of a large casemated work and extensive exterior earthen barbette-batteries for the largest guns and mortars. The casemated part of the work has been completed for some years, and the barbette-batteries should be pushed to completion at an early day.

Amount appropriated for fiscal year ending June 30, 1873, $85,000.

Appropriation asked for next fiscal year, $100,000.

The greater portion of the breast-height walls for twenty heavy guns has been built; eight front-pintle stone platforms for such guns put in position and the masonry of twelve others completed; the pintle and traverse rails for one platform put down; two traverse-magazines have been built, ten others finished, and three-fourths of the masonry of the remaining one are in place; in all, 2,744 cubic yards of stone, brick, and concrete masonry. About one-third of the earth-work of parapets, traverses, and terrepleins for a running length of 1,324 feet of barbette-batteries has been embanked and sodded; also the traverses of the mortar-battery. Total, 18,200 cubic yards of embankment, and 4,605 square yards of sodding. The outer and inner doors for twelve traverse-magazines have been made and hung, and if necessary these magazines can be used. The exposed iron-work of the Totten embrasures of the fort, and of the verandahs of its gorge, has been repainted. Vehicles and buildings, &c., have been repaired, and much miscellaneous work done.

Fort at Lime Point, San Francisco Harbor, California, in charge of Major George H. Mendell, Corps of Engineers.—This fort, with its detached earthen barbette-works at Point Cavallo, Lime Point Ridge, and Gravelly Beach, constitute the defenses of the entrance to the harbor of San Francisco on the northern shore of the Golden Gate. The work performed at Lime Point during the past year may be briefly summarized as follows: At Gravelly Beach battery two magazines were completed; six magazines were covered with earth and sodded; a breast-height timber revetment was put up, parapets completed, and concrete foundations for the guns put in; 12,800 yards of earth-work, 396 yards of concrete masonry, and 1,140 square yards of sodding were finished. This battery requires for completion twelve gun-platforms and some embankment on the flanks. At Lime Point Ridge the breast-height walls for four front and for five center-pintle guns were built of masonry; four magazines built, covered with earth and sodded; four stone platforms for front-pintle 15-inch-gun carriages were completed, as well as the parapets for nine guns and for the six mortars, 15,000 cubic yards of earth-work, 1,970 cubic yards of concrete masonry, 233 cubic yards of brick masonry, and 6,135 square yards of sodding. This battery is complete, except five wooden center-pintle platforms and

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three mortar-platforms. Three mortar-platforms were made and placed; one platform is in an unfinished condition. At Point Cavallo battery a road to its site was partially made, and a beginning made on the excavation.

Amount appropriated for fiscal year ending June 30, 1873, $75,000.

Appropriation asked for next fiscal year, $150,000.

During the present year it is proposed to go on with the construction of the batteries at Point Cavallo, and to finish the batteries at Gravelly Beach and on the Ridge.

Fort on Alcatraz Island, San Francisco Harbor, California, in charge of Major George H. Mendell, Corps of Engineers.—This work occupies an important position for the defense of the entrance to, and inner waters of, the harbor of San Francisco, covering the whole of the rocky island, the shores of which rise abruptly from the water to a height sufficient to secure it from surprise. In battery IV, during the past year, breast-height walls for two guns were built; the parapets were made and sodded; the magazine was completed; three magazines in battery II were covered and sodded; the slopes in rear of batteries 2 and 4 were covered with earth; the foot-wall of this slope was extended 50 feet in battery II; the north *caponnière*, now a large magazine, was covered with concrete, plastered, and partly covered with earth, and the communication to this magazine, and a shell-room adjoining, were advanced more than half toward completion. In battery V, two granite platforms for 15-inch guns, with the circular breast-height walls, were built, and the parapets made and sodded; the adjoining service-magazine was completed except its covering; the excavation in this battery and those adjoining was continued, and the excavation in battery V was nearly completed. Communication was established with battery V by a road in rear of the unfinished casemated barrack, round by the southern end of the island, and also by a cut in rear of the battery.

Amount appropriated for fiscal year ending June 30, 1873, $42,500.

Appropriation asked for next fiscal year, $75,000.

During the present year it is proposed to finish the *caponnière*, extend the wall at the foot of the slope in rear of battery I, finish the slope in part, complete the two magazines, the parados passage-way, and the shell-rooms in battery V, and finish its reverse slopes; excavate in battery VI and fill in battery VII; construct at least two gun-platforms and a magazine in one of the other batteries.

Batteries at Point San José, San Francisco Harbor, California, in charge of Lieutenant-Colonel C. S. Stewart, Corps of Engineers.—East Battery.—The wood-work of platforms is much decayed. The wood-work of the magazine is decaying, and roof has settled.

West Battery.—The wood-work of the three platforms on the right is very much decayed. The magazine is still serviceable, and may remain so throughout the year. During the year three 15-inch Rodman guns have been brought to the bluff in rear of this battery. Estimates for these works are deferred for more important positions.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

Batteries on Angel Island, San Francisco Harbor, California, in charge of Lieutenant-Colonel C. S. Stewart, Corps of Engineers.—These three temporary earth-works, constructed during the late war, remain in much the same condition presented by the last annual report, with increased deterioration due to the lapse of time. The wooden platforms are much decayed, and most of the wooden carriages have been condemned. It is proposed to postpone the commencement of batteries of

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a permanent character, projected to replace them, until more advanced points are fortified.

No appropriation was made for fiscal year ending June 30, 1873.

No appropriation asked for next fiscal year.

New Fort at San Diego, California.—Projects for the construction of earthen sea-coast batteries, for guns of the largest caliber, to protect this important harbor of Southern California, have been projected. This work is included in the first class of works to be constructed upon this coast, and an appropriation for the same is recommended of $50,000.

Defenses of the mouth of the Columbia River, Oregon, in charge of Major Henry M. Robert, Corps of Engineers.—These defenses consist of Fort Stevens on the south side, and three detached batteries at Cape Disappointment, Washington Territory, on the north side of the entrance. They are in a very bad condition; the entire wood-work of Fort Stevens, except the magazine, being rotten; the revetment of the interior slopes, all round the fort, are fallen, and several traverses lying in a confused mass of earth and timbers, on the terreplein. All the magazines at Cape Disappointment are so dilapidated as to be useless for any purpose.

The only operations during the past year have been the covering of the powder-house at Cape Disappointment with two coats of fire-proof paint, the erection of a lightning-rod thereon, and the annual surveys of Point Adams and Sand Island, which are made to furnish a record of the changes going on each year by the encroachments of the sea.

The question of the restoration of these works has been referred to the board of engineers for the Pacific coast, and their modification is now under its consideration.

No appropriation was made for fiscal year ending June 30, 1873.

Appropriation asked for next fiscal year, $20,000.

Sea-coast mortar-batteries.—The appropriation for sea-coast mortar-batteries, approved June 10, 1872, was distributed as follows:

At New York, Fort Hamilton, for 8 mortars, $24,000.
At New York, Staten Island, for 8 mortars, $24,000.
At Finn's Point, opposite Fort Delaware, for 6 mortars, $20,000.
At fort opposite Fort Delaware, Delaware, for 6 mortars, $20,000.
At Fort Point, San Francisco, for 4 mortars. $12,000.

Making a total of thirty-two mortars.

Detailed reports of the progress made upon these batteries are contained in the reports of the works at which they are constructed.

A further appropriation for the emplacement of this most important arm of defense is requested.

Amount appropriated for fiscal year ending June 30, 1873, $100,000.

Appropriation asked for next fiscal year, $100,000.

BOARDS OF ENGINEERS.

The board of engineers for fortifications, stationed in New York City, consisting of Colonel J. G. Barnard, Colonel G. W. Cullum, Lieutenant-Colonel Z. B. Tower, and Lieutenant-Colonel H. G. Wright, has submitted, during the past year, reports on the modifications required for the use of King's depressing gun-carriage, in the defenses of Portland Harbor, of Delaware River, of the harbor of New York, of the harbor of San Francisco, of Charleston Harbor, of Newport Harbor and Narragansett Bay; it has also reported on the modifications of Fort Jefferson, Florida, upon additional defenses for Portsmouth Harbor, New Hampshire, upon the modification of Fort Pulaski, Tybee Roads; upon the defenses of Buffalo and the mouth of Niagara River. It has likewise

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submitted plans for mortar-batteries in the defenses of Delaware River and of Boston Harbor.

Incidentally to its more ordinary duties, the board has prepared a plan for a new barrack for Fort Monroe, and examined and reported upon various projects of individuals for objects connected with harbor-defense, viz: Moody's floating battery; Fisher's plan of floating forts; Captain King's carriage for heavy mortars; the same officer's plan for mounting his gun-carriage where space is limited; Foye's method of strengthening walls of buildings and other walls of masonry; Private Link's devices for torpedoes.

The board has also submitted a report upon the question of the exposure to which guns and gunners in ordinary barbette batteries are subjected owing to the curved trajectories of modern projectiles, and of the best method of procuring additional cover, independently of the use of depressing-carriages, recommending increased height of the covering line above the terreplein, and adding to the height of the barbette top carriage.

Besides the operations thus recapitulated, the individual members of the board have served during the year on various boards and commissions.

Torpedoes.—The board was instructed in May, 1869, to take into consideration projects for the application of torpedoes to harbor-defense, the commanding officer of the engineer battalion being associated with it for that purpose. The project for the experimental investigation of the subject submitted by the board having been duly approved, the latter officer proceeded to carry it into execution, the engineer troops supplying the manual labor. As the result of this investigation thus far, good chemical and electrical laboratories have been established at Willet's Point; the laws governing sub-aqueous explosions, the relative merits of most of the modern explosive agents, and the several methods of ignition, have all received thorough and scientific investigation by new methods and apparatus; the practical experience requisite to decide upon the best form of insulated cable for torpedoes has been gained; the main features of an electrical-torpedo defense of our harbors have been determined; and although much still remains to be done in experimental investigation, the board has prepared a satisfactory estimate of the sum necessary for an efficient torpedo-defense of our harbors in case of war with a maritime power.

The board has invited the attention of the Chief of Engineers to the probable difficulty which would be encountered, in the event of a sudden war, in making the preparations requisite for this accessory to the proper defense of our principal harbors; and submits an estimate of the cost of its application to some twenty harbors, amounting to the sum of $2,000,000.

While it is not recommended by the board that all the material for such defense should be provided at once, it seems imperative to procure and keep on hand a moderate allowance of such of the appliances as require a considerable time for preparation, and for this purpose the board recommends an appropriation of $1,000,000.

The *board of engineers for the Pacific coast*, consisting of Lieutenant-Colonel B. S. Alexander, Lieutenant-Colonel C. S. Stewart, and Major George H. Mendell, with Captain Thomas H. Handbury as recorder, has been engaged during the past year in perfecting the details of the water-batteries now under construction at Fort Point, Lime Point, and Point Cavallo, San Francisco Bay; in preparing projects for the field-works that will be necessary in the event of war to protect the rear of

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the permanent sea-coast defenses at Fort Point and its vicinity; in making current observations, with a view of determining to what extent torpedoes and floating obstructions can be relied on as auxiliary means of defense in time of war in San Francisco Bay, at and near the mouth of the Columbia River, Oregon, and at the entrances to Admiralty Inlet and Puget's Sound, Washington Territory; in making a reconnoissance of Lake Washington, Washington Territory, and the vicinity, with the view of ascertaining the adaptability of this lake for a naval depot, and the proper route for a ship-canal to connect it with Admiralty Inlet, and the cost of such canal; in making an examination of San Diego Harbor, and a resurvey of a portion of that harbor, in order to ascertain if the upper part of it is now being filled up by natural causes; in making military surveys of the Presidio and Lime Point reservations; and in preparing plans for permanent barracks for soldiers at Alcatraz Island, San Francisco Harbor.

BATTALION OF ENGINEERS AND DEPOTS.

Battalion of Engineers, commanded by Major Henry L. Abbot, Corps of Engineers, headquarters Willet's Point, eastern entrance to New York Harbor.

The strength of the five companies constituting the battalion of engineers, on the 30th of June, 1872, was 14 officers and 315 enlisted men; 45 recruits were needed to complete the reduced organization fixed by General Orders No. 122, series of 1870, from the War Department. This organization, in accordance with the act of July 15, 1870, was determined to be as follows: Companies A, B, C, and E, 83 enlisted men each; Company D, 20 enlisted men; non-commissioned staff of battalion, 2 men; making a total of 354 enlisted men of engineers.

The companies of the battalion were stationed and commanded as follows: At Willet's Point, Company A, Captain A. Mackenzie; Company B, Captain W. R. King; Company C, Captain C. W. Raymond; Company D, (a skeleton organization,) under command of the battalion adjutant.

At West Point, Company E, Captain O. H. Ernst, also instructor of practical engineering, and *ex-officio* member of the academic board.

Detachments of one sergeant and five first-class privates of Company D were stationed at Jefferson Barracks, Missouri, guarding and caring for the engineer property there; one sergeant and four first-class privates on field-duty in the Department of the Missouri, under direction of the engineer officer of the Department; three men on recruiting duty at New York City, and three at Detroit, Michigan.

Owing to the destruction by fire of the depot at Yerba Buena Island, California, the detachment of one sergeant and five first-class privates was ordered to Willet's Point, where it arrived August 11, 1871.

The system of drawing recruits by selection from the general depot having failed to meet the requirements of the engineer service, two officers of the corps, one at New York City, and one at Detroit, Michigan, were detailed by orders from the War Department to enlist men for the battalion at those places, in addition to their other duties. During the year 129 men were enlisted, 56 re-enlisted, and 79 deserted.

During the year the battalion has been engaged as follows: At Willet's Point the engineer depot has been guarded, and the property and instruments received and issued by the troops. The removal of a large part of the material to a new store-house, and its careful arrange-

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ment, have been accomplished. The property at the Jefferson Barracks depot has been cared for by the detachment there stationed.

At West Point similar work has been performed by Company E, has also been employed in duties connected with the instruction of cadets in practical engineering, pontoniering, signaling, &c. At Willet's Point much labor has been performed by the troops upon the new buildings, the cost of which has thereby been materially reduced.

The drills and instruction of the battalion at Willet's Point have been such as to keep it always ready for active service, and good progress has been made in field-fortification, pontoniering, military reconnaissance, photography, infantry tactics, &c. Theoretical instruction of the non-commissioned officers was had during suspension of drills in the winter, and the school for enlisted men, directed by General Orders, No. 56, Adjutant General's Office, 1866, was open to voluntary attendance under the personal supervision of the commissioned officers.

Every effort has been made to give the officers, stationed at this post, the advantages enjoyed at schools of practice abroad. During the winter months each officer was required, by authority of the honorable Secretary of War, to prepare two papers upon some professional subject involving the duties now performed by the Engineer Department or those required of engineer troops and engineer staff-officers in time of war. These papers were of a creditable character, and were laid before the examining board for promotion.

The work of the torpedo-school has been actively prosecuted, and the results obtained are highly satisfactory, and will be made the subject of special report when experiments are completed.

I would respectfully recommend an appropriation of $1,000 for the purchase of engineering material to continue the present system of instruction of the battalion, and of $10,000, to be expended in experiments, apparatus, &c., for the torpedo-school, and again urge my recommendations of former years, that the battalion be allowed two principal musicians, and that the seventh section of the act of July 13, 1866, taking from engineer troops the per diem paid to other soldiers, when engaged in continuous labor, be repealed.

Engineer post and depot at Willet's Point, New York Harbor, commanded by Major Henry L. Abbot, Corps of Engineers.—This post is the principal engineer depot of the Army, where, under guard of the battalion, are stored the bridge-equipage, siege and mining tools, &c., left on hand at the end of the war. Such portions of this property as can be used to advantage on public works in charge of the Corps of Engineers, are issued, from time to time, as needed. The store-houses have been put in a satisfactory condition during the past year, and the property is now secure against injury, except the pontons, which will be protected from the weather during the coming season. It is advisable that certain parts of the bridge-equipage should be made to conform with the new patterns adopted in 1869, after much experience in the war. For this object, and for the current expenses of the depot, an appropriation of $3,000 is requested; the labor will be chiefly performed by the troops.

Work upon the public buildings has been rapidly pushed forward during the past year. Six new buildings have been completed, and seven old ones renovated. The funds now available are sufficient to complete the necessary work in hand, of which the cost has been greatly reduced by the labor of the engineer troops.

This post is now the storage and issuing depot of astronomical, geodetic, reconnoitering, &c., instruments, for the use of the Corps of En-

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gineers. It is desirable, in order to avoid loss of time, to keep on hand a small supply of such instruments as are in constant demand, and also to be able to promptly repair unserviceable instruments turned in for that purpose. An appropriation of $5,000 is accordingly requested.

Depot of engineer stores at Jefferson Barracks.—A supply of engineer material, principally ponton-trains, is still stored at this post, now under charge of the Ordnance Department, and a detachment of one sergeant and five first-class privates, from Company D, engineers, is attached to this post for the purpose of caring for this property.

Depot of stores at Yerba Buena Island, California.—The engineer property stored at this post having been destroyed by fire on the 3d of May, 1871, the small detachment of Company D, left there to guard it, was ordered to Willet's Point.

RIVER AND HARBOR IMPROVEMENTS.

The act making appropriation for the "repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," approved March 3, 1871, furnished the means of continuing the work on certain improvements specified therein, and enumerated in my last annual report; and the amounts therein appropriated, together with such balances of previous appropriations as were legally available, have been applied to the several improvements respectively.

The works have been prosecuted in a satisfactory manner by the officers in charge, in accordance with approved plans; the rate of progress in each case depending much upon the exigencies of the seasons at the different localities, and also upon the character and reliability of the contractors.

The surveys and examinations directed to be made by the third section of the act of March 3, 1871, with a view to the improvement of certain rivers and harbors, have been completed, and the reports with results, excepting in the case of the Horseshoe Shoals in the Delaware River, were transmitted to Congress during the last session. A portion of these reports may be found printed in my last annual report. The remaining, including Horseshoe Shoals, are transmitted herewith.

By the act approved June 10, 1872, making appropriations for improvements of certain rivers and harbors and for other purposes, Congress furnished the means for continuing the works provided for in previous acts, and also for improvements at certain localities, the surveys and examinations of which had been made and results reported in accordance with previous enactments. The officers in charge of the several districts were notified at once of the amounts appropriated for the improvements then in progress, and, as soon as the funds became available, were directed to apply the same to the prosecution of the works.

In the case of improvements at localities for which appropriations have not heretofore been made, they were directed to submit projects, and, on approval, instructions have been issued for commencing operations.

The examinations and surveys at certain localities, named in the second section of this act, and directed to be made with a view to the improvement of rivers and harbors, were commenced at as early a day as practicable after the passage of the act, and it is hoped that the field-work will be completed during the present season, and the results of the greater portion prepared in time for transmission to Congress during the next session.

A brief summary of the amount of work done at each locality since

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my last annual report, and the present condition of the improvement, together with a statement showing the amount expended during the fiscal year, and the amount that can be profitably expended during the next fiscal year, is submitted herewith.

For more detailed information in regard to the improvements, and for the results of the surveys and examinations ordered by Congress, and not found in my last annual report, I beg to invite attention to the sub-reports which may be found in the appendix to this.

HARBORS ON LAKE SUPERIOR AND ON THE WEST AND SOUTH SHORES OF LAKE MICHIGAN—IMPROVEMENT OF FOX AND WISCONSIN RIVERS.

Officer in charge, Major D. C. Houston, Corps of Engineers, having under his immediate orders Captains J. W. Cuyler and A. M. Miller, Corps of Engineers.

1. *Du Luth Harbor, Lake Superior, Minnesota.*—The appropriation of $60,000 by the act of March 3, 1871, has been applied to the extension and repairs of the breakwater built by the railroad company.

The total extension is 400 feet, making the total length of the breakwater 950 feet. The appropriation of this year, $50,000, will be applied to its further extension, which will make the breakwater 1,200 or 1,250 feet in length. The canal cut through Minnesota Point by the city of Du Luth has been enlarged and protected by piers extending into the lake, and affords a channel by which vessels of all classes have access to the bay or inner harbor of Du Luth.

Extensive wharves have been constructed in the inner harbor by the Northern Pacific Railroad Company.

A dike has been constructed, connecting Rice's Point with Minnesota Point, in compliance with the requirements of the Government, for the purpose of preventing a divergence of the waters of the Saint Louis River through the canal, by which it was feared that such a diminution of scour at the "natural entry" to the Bay of Superior, as would result in injury to the latter, would take place. This dike has not been completed according to the requirements of the Government.

At the same time, in consequence of the prosecution of the works of improvement at the entry, the channel at that point has deepened, the present season. In the opinion of the officer in charge, there does not appear to be any necessity for the further extension of the breakwater in view of the improvements which have been made in the inner harbor and canal, but he thinks the sum of $50,000 can be advantageously expended upon the breakwater.

A statement of the action of this office in regard to the canal and dike, constructed by the city of Du Luth through Minnesota Point, was transmitted to Congress April 12, 1872, with copies of the correspondence in relation to it. This statement, omitting the correspondence, will be found in Appendix A 21.

Amount available July 1, 1871	$60,000 00
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872, including $4,948.23 retained from payments to contractors	55,934 72
Amount available July 1, 1872	54,065 28
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendixes A 1 and 22.)

2. *Superior City Harbor, Lake Superior, Wisconsin.*—The plan adopted for this harbor was to construct two parallel piers to extend to 18 feet water in the lake.

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During the year the Minnesota pier has been extended 768 feet, and the Wisconsin pier 1,184 feet, so that the Minnesota pier has entirely crossed the bar, and the Wisconsin pier has passed over its crest.

The effect of this extension has been to confine the current and increase its scouring effect upon the bar. The least depth reported (October 4, 1872) was over 12 feet, except for a distance of about 100 feet, where the depth was 11 feet.

A scraper has been used to loosen the material composing the bar, (sand and gravel,) so as to give the full effect to the transporting power of the current. The result has been a marked increase in the depth of water on the bar. It is proposed during the year ending June 30, 1872, to extend the Minnesota pier 200 feet and the Wisconsin pier 600 feet, and if it should be found necessary to dredge out the channel. This will complete the pier-extension deemed necessary at present.

There will remain, to complete the work, the superstructure over nearly the whole extent of the piers, for which the sum of $40,000 is estimated.

Amount available July 1, 1871	$89,208 90
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872, including $4,759.58 retained from payments to contractors	80,822 17
Amount available July 1, 1872	58,386 73
Amount required for fiscal year ending June 30, 1874	40,000 00

(See Appendix A 2.)

3. *Ontonagon Harbor, Lake Superior, Michigan.*—During the past season the west pier has been extended 224 feet, thus exhausting the available funds. No appropriation has been made for this harbor since 1870.

Amount available July 1, 1871	$14,059 96
Amount expended during the fiscal year ending June 30, 1872	13,506 74
Amount available July 1, 1872	553 22
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendix A 3.)

4. *Eagle Harbor, Lake Superior, Michigan.*—No work has been done at this harbor during the year; and, as stated in the last annual report, the work has been suspended, it being deemed advisable to await the results of the operations for removing rock obstructions in Hell Gate, East River, New York, before deciding upon a plan for prosecuting this work.

Amount available July 1, 1871, reported in last annual report	$23,556 57
Above report in error	1,501 11
Amount expended during the fiscal year ending June 30, 1872	249 00
Amount available July 1, 1872	24,808 68

(See Appendix A 4.)

5. *Marquette Harbor, Lake Superior, Michigan.*—During the year the breakwater has been extended 550 feet up to water-surface, and superstructure completed over 300 feet of previous work. It is estimated that with the appropriation of this season the breakwater can be extended 250 feet, including superstructure over all. This will complete the work as originally designed, except covering the breakwater, putting on a pier-head, &c., requiring the sum of $15,000. It is probable that the future commerce of Marquette may demand an extension of this work.

Amount available July 1, 1871	$85,017 91
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872, including $4,036.23 retained from payments to contractors	68,704 65
Amount available July 1, 1872	66,313 26
Amount required for fiscal year ending June 30, 1874	15,000 00

(See Appendix A 5.)

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6. *Menomonee Harbor, Michigan and Wisconsin.*—During the year, 1,150 feet of the south pier have been completed in accordance with the plan adopted for the improvement of this harbor.

During the year ending June 30, 1873, and, it is hoped, the present season, the south pier will be further extended 400 feet, and the north pier extended out to the same distance. This will carry both piers over the crest of the bar, and confine the waters of the Menomonee River to a channel 400 feet in width, so that it is probable that the freshets of the coming season will scour out a channel. The completion of the work, as designed, will require the extension of the piers to a depth of 14 feet.

Amount available July 1, 1871	$24,772 50
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during the fiscal year ending June 30, 1872, including $1,986.54 retained from payment to contractors	22,150 98
Amount available July 1, 1872	27,621 52
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendix A 6.)

7. *Green Bay Harbor, Wisconsin.*—The work at this harbor has consisted in widening and deepening the channel from the mouth of Fox River to Grassy Island, so that at the close of the season of 1871, there was a channel 14 feet deep at the ordinary stage of water of the season, and 200 feet in width, except for the distance of about one mile, where the channel is but 160 feet in width. Notwithstanding this, the variation in the water-level at this harbor is so great that vessels are reported as occasionally grounding in the channel. The extreme variation in the water-level during the season of 1871 was 5 feet and 5 inches.

The importance of this harbor requires a channel of sufficient capacity to admit the passage of vessels drawing 13 feet at all times. To effect this, and to straighten the channel, will require the removal of about 175,000 cubic yards of material, at an estimated cost of $50,000.

Amount available July 1, 1871	$19,316 79
Amount expended during the fiscal year ending June 30, 1872	18,856 02
Amount available July 1, 1872	460 77
Amount required for fiscal year ending June 30, 1874	25,000 00

(See Appendix A 7.)

8. *Manepee Harbor, Lake Michigan, Wisconsin.*—During the year two pile-piers have been constructed in the lake, one on the north of the river-mouth, 352 feet in length, and one on the south, about 200 feet in length. It is expected, during the year ending June 30, 1873, to extend these piers out to 12 feet depth of water, requiring the construction of about 300 feet of pier, and to dredge out a channel into the river. Having accomplished this, the harbor will be in a favorable condition for future operations in constructing an outer harbor, as originally contemplated.

Amount available July 1, 1871	$24,830 60
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during the fiscal year ending June 30, 1872, including $362.82 retained from payments to contractors	13,028 10
Amount available July 1, 1872	36,802 50
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendix A 8.)

9. *Two Rivers Harbor, Wisconsin.*—In accordance with the plan determined on for the improvement of this harbor, the first appropriation has been expended in construction of two parallel pile-piers, one on the east, and the other on the west side of the river-mouth. Each pier is

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416 feet in length. The present appropriation will be applied to the further extension of the piers.

Amount available July 1, 1872	$24,968 70
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during the fiscal year ending June 30, 1872	21,684 21
Amount available July 1, 1872	28,284 49
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendix A 9.)

10. *Manitowoc Harbor, Wisconsin.*—During the year an extension has been made to each pier of 96 feet, the cribs being built up to one foot above the water-level, and the superstructure built over work done in 1870. During the season the superstructure will be completed over the work of last season, and guard-piles driven along the face of the piers. No appropriation was made for this harbor at the last session of Congress, and none was asked for, as the amount of the original estimate had been reached.

The importance of this harbor, as shown in accompanying report, requires that the piers be extended to a depth of 18 feet of water, at an estimated cost of $80,000.

Amount available July 1, 1871	$20,459 04
Amount expended during the fiscal year ending June 30, 1872, including $836.92 retained from payments to contractors	9,880 08
Amount available July 1, 1872	10,578 96
Amount required for fiscal year ending June 30, 1874	40,000 00

(See Appendix A 10.)

11. *Sheboygan Harbor, Wisconsin.*—During the year the north pier has been extended 320 feet and the south pier 128 feet up to water-surface. During the present season a further extension of 50 feet will be made to each pier, completing the pier-extension for the present.

The channel between the piers will also be dredged out. It will be necessary, in addition to this work, to thoroughly repair the old piers. An estimate was made for this purpose last year, but a sufficient sum was not appropriated. The sum of $10,000 will be required for this purpose.

Amount available July 1, 1871	$29,086 70
Amount appropriated by act of June 10, 1872	18,000 00
Amount expended during the fiscal year ending June 30, 1872, including $928.48, retained from payments to contractors	28,856 95
Amount available July 1, 1872	18,229 75
Amount required for fiscal year ending June 30, 1874	10,000 00

(See Appendix A 11.)

12. *Port Washington Harbor, Wisconsin.*—During the year two piers have been constructed in the lake, each 300 feet in length, one on the north and one on the south side of the harbor-mouth. A considerable amount of dredging was done by the town of Port Washington.

The work proposed to be done under the appropriation of June 10, 1872, is the extension of each pier 100 feet, and as much excavation in the channel and basin. Owing to the character of the bottom at this locality, a stiff clay, the work done has remained permanent, and the result has been most satisfactory. No further extension of the pier and excavation of the basin is required for the completion of this harbor.

Amount available July 1, 1871	$20,542 70
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during the fiscal year ending June 30, 1872	18,978 69
Amount available July 1, 1872	16,564 01
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendix A 12.)

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13. *Milwaukee Harbor, Wisconsin.*—During the year each pier has been extended 350 feet, the heads of the piers being in 17 feet of water at the ordinary stage.

During the present season the superstructure will be completed over these extensions, and the necessary repairs be made to old work. An estimate of $10,000 is submitted for dredging the channel between the piers.

Amount available July 1, 1871	$75,121 79
Amount expended during the fiscal year ending June 30, 1872, including $2,470.98 retained from payments to contractors	53,291 03
Amount available July 1, 1872	21,830 76
Amount required for fiscal year ending June 30, 1874	10,000 00

(See Appendix A 13.)

14. *Racine Harbor, Wisconsin.*—During the season of 1871 the south pier was extended 256 feet. The superstructure over this extension was completed this season.

It is deemed necessary, for the proper improvement of this harbor, to extend the north pier 150 feet further, as explained in the accompanying report.

Amount available July 1, 1871	$17,285 65
Amount expended during the fiscal year ending June 30, 1872, including $546.25 retained from payments to contractors	13,120 88
Amount available July 1, 1872	4,164 77
Amount required for fiscal year ending June 30, 1874	20,000 00

(See Appendix A 14.)

15. *Kenosha Harbor, Lake Michigan, Wisconsin.*—During the year the crib at the outer end of the north pier, displaced by a storm in March, 1871, has been protected by close piling, and another crib, 50 feet by 30 feet, placed in extension of the piers. It is proposed to apply the appropriation of June 10, 1872, to extending the north pier 50 feet by a crib 30 feet by 30 feet, to repair the south pier, and protect the heads of the piers by piles. The sum of $15,000 is estimated for dredging out the channel between the piers, there being at present but 9½ feet at the ordinary stage of water.

Amount available July 1, 1871	$13,307 79
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during the fiscal year ending June 30, 1872, including $447.2[illegible] retained from payments to contractors	5,408 79
Amount available July 1, 1872	17,899 00
Amount required for fiscal year ending June 30, 1874	15,000 00

(See Appendix A 15.)

16. *Chicago Harbor, Illinois.*—During the year the breakwater has been extended southward 800 feet, and a return, 300 feet in length, constructed at the north end of the work.

At the close of the fiscal year ending June 30, 1872, the breakwater stood 2,250 feet in length, complete, with the exception of the covering and a small quantity of superstructure at the south end. During the fiscal year ending June 30, 1873, it is expected, with the present appropriation of $90,000, to extend the breakwater to the south 800 feet, and to plank over the present work.

A modification of the cross-section of this breakwater having been proposed by Major Houston, he was authorized to adopt it in part, and to so far modify the original project as to introduce, in future, stone foundations for the cribs, of such dimensions as his judgment might dictate, but limiting their heights for the present to 12 feet below the

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water-surface. The reasons for this change, with its expected advantages, will be found fully explained in Appendix A.

Amount available July 1, 1871	$120,405 23
Amount appropriated by act of June 10, 1872	90,000 00
Amount expended during the fiscal year ending June 30, 1872, including $8,617.02 retained from payments to contractors	112,244 12
Amount available July 1, 1872	98,161 11
Amount required for fiscal year ending June 30, 1874	200,000 00

(See Appendixes A 16 and 23.)

17. *Calumet Harbor, Illinois.*—The operations of the year have consisted in the construction of the south pier, and the extension of the north pier, making in all 1,700 feet of pier and revetment. The channel has been widened and deepened by dredging.

The operations proposed for the fiscal year ending June 30, 1873, are the further extension of the north pier, and continuing the excavation of the channel. It is estimated that the north pier can be extended out to a depth of 14 feet of water, which will entirely protect the narrow channel which it is proposed to excavate.

The sum of $75,000 is estimated for the next fiscal year.

Amount available July 1, 1871	$65,903 07
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during the fiscal year ending June 30, 1872	59,637 97
Amount available July 1, 1872	46,265 10
Amount required for fiscal year ending June 30, 1874	75,000 00

(See Appendix A 17.)

18. *Michigan City Harbor, Indiana.*—The operations at this harbor have consisted in dredging out the channel between the piers, and in repairing and covering the piers. There is now a 14-feet channel between the piers.

During the present season work will be commenced in the outer harbor, under the appropriation of $50,000 made at the last session of Congress.

The sum of $100,000 is estimated for the prosecution of this work during the next fiscal year.

Amount available July 1, 1871	$26,916 36
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872	17,166 81
Amount available July 1, 1872	59,749 55
Amount required for fiscal year ending June 30, 1874	100,000 00

(See Appendix A 18.)

19. *New Buffalo Harbor, Michigan.*—During the year the piers commenced in the spring of 1871 have been extended into the lake 301 feet.

The small amount appropriated for this harbor, $5,000, was not sufficient to produce any beneficial result.

The appropriation of this year, $5,000, will be applied to commencing the west pier. In order to accomplish any permanent benefit at this harbor, and to enable the work to be carried on to advantage, a sufficient sum to extend the piers out to a depth of 10 feet of water is required. The piers would then protect a channel when excavated.

Amount available July 1, 1871	$8,238 56
Amount appropriated by act of June 10, 1872	5,000 00
Amount expended during the fiscal year ending June 30, 1872, including $552.21 retained from payments to contractors	4,414 33
Amount available July 1, 1872	8,824 23
Amount required for fiscal year ending June 30, 1874	75,000 00

(See Appendix A 19.)

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20. *Improving Wisconsin River.*—The work of improving the navigation of this river by the construction of dams and jettees has been carried on throughout the year.

The results of last season's work (see Appendix A) led to the belief that by the plan adopted it would be practicable to improve the natural channel of the river so as to obtain a navigation for vessels drawing 4 feet of water.

These operations have been continued during the present working season with satisfactory results. At the close of the season a report will be made giving the results obtained.

Amount available July 1, 1871	$106,902 95
Amount expended during the fiscal year ending June 30, 1872	55,781 92
Amount available July 1, 1872	51,121 03
Amount required for fiscal year ending June 30, 1874	250,000 00

(See Appendixes A 20 and A 21.)

In March last (8th) the Secretary of War transmitted to the House of Representatives the report of the arbitrators selected under the act of Congress, entitled "An act for the improvement of water-communication between the Mississippi River and Lake Michigan, by the Wisconsin and Fox rivers," approved July 7, 1870. The Secretary approved the award of the arbitrators, and stated it as his opinion that the sum of $325,000 ought in justice, to be paid to the Green Bay and Mississippi Canal Company as an equivalent for the transfer to the United States of all the property, rights, and franchises embraced in the award of the arbitrators, provided Congress should determine to purchase the whole thereof. He, however, was of opinion that the personal property appraised by the arbitrators at $40,000, and that the franchises of the corporation appraised at $140,000, were not requisite for purposes of navigation, and therefore not needed. Deducting the above from the total award, $325,000, would leave, for the remaining property, franchises, &c., needed, $145,000, the amount which ought, in justice, to be paid to the corporation.

The act making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, approved June 10, 1872, based upon the above recommendation of the Secretary of War, appropriated the sum of $145,000 "for payment to the Green Bay and Mississippi Canal Company for so much of all and singular its property and rights of property in and to the line of water-communication between the Wisconsin River and the mouth of the Fox River, including its locks, dams, canals, and franchises, as were, under the act of Congress for the improvement of water-communication between the Mississippi River and Lake Michigan, by the Wisconsin and Fox rivers, approved July 7, 1870, reported by the Secretary of War to be needed, in his communication to the House of Representatives, dated March 8, 1872."

In conformity with the requirements of the act referred to, the sum of $145,000 has been paid to the Green Bay and Mississippi Canal Company, and they have transferred the property to the United States.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

The third section of the act of March 3, 1871, required a survey for a ship-canal from the head of Sturgeon Bay, Wisconsin, to Lake Michigan, "with estimates for constructing the same 100 feet wide and 13 feet deep." This survey was completed during the season of 1871, and the report thereon transmitted to Congress at its last session.

(See Appendix A 24.)

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Major Houston has also been charged with the following examinations, provided for in section two of the act of June 10, 1872:

1. *At mouth of Grand Calumet River, Indiana.*
2. *At mouth of Pensaukie River, Michigan.*
3. *At Wankegan Harbor, Illinois.*

HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN.

Officers in charge, Major F. U. Farquhar, Corps of Engineers, to June 13, 1872; since which time Captain S. M. Mansfield, Corps of Engineers.

1. *Frankfort Harbor, Michigan.*—During the past year a north pier-extension of 64 feet was completed, and the superstructure carried over the interior 64-foot crib sunk the previous year. An extension of 128 feet has been added to the south pier.

During the present season the south pier will be extended one crib, (65 feet,) leaving the piers of even length, and the unexpended balance of money appropriated will be expended in the spring in dredging the channel.

A further addition of 264 feet to each pier will be required to complete the work designed, and will cost the estimate of last year, $56,000, less the present appropriation, $10,000, or $46,000. This extension can be accomplished in one season if the sum required is available early.

Amount on hand July 1, 1871, including forfeiture on contract of November 11, 1870	$10,030 02
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	10,028 37
Amount on hand July 1, 1872	10,001 65
Amount required for fiscal year ending June 30, 1874	46,000 00

(See Appendixes B 1 and *b* 1.)

2. *Manistee Harbor, Michigan.*—Each pier was extended 158 feet, but the north pier still required superstructure. The 30 feet of each pier furthest west were built 30 feet wide, being intended for pier-heads. The work of completing the north pier, and of repairing the south pier, burned last fall, will completely exhaust the funds on hand.

To complete the inside work of this harbor, as heretofore designed, will require to be constructed 280 feet of revetment to north shore and 580 feet to south shore, with 13,046 cubic yards dredging to straighten and widen the channel.

Amount on hand July 1, 1871, including forfeiture on contracts of September 8, 1870, and April 17, 1871	$20,396 88
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	19,397 93
Amount available July 1, 1872	10,998 95
Amount required as above for fiscal year ending June 30, 1874	19,760 50

(See Appendixes B 2 and *b* 2.)

3. *Pere Marquette Harbor, Michigan.*—The operations at this harbor comprise a pier-head placed on north pier-extension, 135 feet of pile-pier east from south crib-pier, and dredging from the channel and from the old slab pier on the south side of the channel.

The work of the fiscal year consisted in the removal of part of the old slab pier on the south side and revetting opposite the portion removed. To finish this work will require an additional appropriation of $25,440.

The piers should be extended 250 feet each, to obtain 12 feet water and remove a bad bar which has formed outside the harbor; $40,000 will effect this.

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Amount on hand July 1, 1871	$9,792 33
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	9,792 20
Amount available July 1, 1872	10,000 13
Amount required for fiscal year ending June 30, 1874	65,440 00

(See Appendixes B 3 and *b* 3.)

4. *Pent Water Harbor, Michigan.*—A large portion of the funds available was spent in dredging. A north pier-head was built, and, after settling during the winter, was releveled. The south pier was connected with the shore by building 95 feet of pile-pier.

The present appropriation of $30,000 will be applied this season to the removal of the old south slab pier and revetment of the channelway.

There will be needed a further appropriation of $24,780 to complete this work.

Amount on hand July 1, 1871	$10,085 04
Amount appropriated by act of June 10, 1872	30,000 00
Amount expended during fiscal year ending June 30, 1872	10,076 22
Amount on hand July 1, 1872	30,008 82
Amount required for fiscal year ending June 30, 1874	24,780 00

(See Appendixes B 4 and *b* 4.)

5. *White River Harbor, Michigan.*—The westward extension to each pier during the past fiscal year was as follows:

North pier, piling for 136 feet and superstructure over 160 feet. The western section, 40 feet square, intended for a pier-head, still lacks superstructure. South pier, 96 feet of piling, 68 feet of which has received superstructure, while 28 feet is yet uncovered. The north pier-head was completed.

The present appropriation will be entirely expended this season in ballasting the piers and dredging, the work for which it was intended.

To make the piers complete, as originally designed, and as called for in 1870, the south pier should be extended 136 feet, even with the north pier, at a cost of $6,940.

Amount on hand July 1, 1871	$13,925 74
Amount received from sale of hull and boiler of tug Robert Emmett	350 00
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	13,643 66
Amount on hand July 1, 1872	10,632 08
Amount required for fiscal year ending June 30, 1874	6,940 00

(See Appendixes B 5 and *b* 5.)

6. *Muskegon Harbor, Michigan.*—The construction of a pier-head crib, with superstructure over this and the two cribs next interior, sunk in previous years, leaves the north pier complete. A breach through the slab pier, where it joins the south Government pier, was closed with 34 feet of pile-pier.

During the present season the funds on hand will accomplish all that is at present necessary.

The harbor will be left in excellent condition, and no further appropriation is asked.

Amount on hand July 1, 1871	$13,513 64
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	11,825 53
Amount on hand July 1, 1872	11,688 11

(See Appendixes B 6 and *b* 6.)

7. *Grand Haven Harbor, Michigan.*—During the last season 460 feet of repairs were completed.

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During the present season, up to the close of the fiscal year, nothing was done, the entire amount available having been exhausted.

The old work is in about the same condition as last year, with the exception of the inner revetment, which is rapidly going to pieces.

During this season some necessary repairs will be put upon the outer work, and 600 feet of revetment (inward from the work of last season) will be built.

I renew the recommendations made in former reports for a pier-head, to cost $7,000; a north pier, $200,000; and the repairing and replacing of the inner revetment, which will need a further appropriation of $26,300. Of this total—$233,300—$100,000 can be advantageously expended during the year ending June 30, 1874.

Amount available July 1, 1871	$7,051 75
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during fiscal year ending June 30, 1872	7,054 50
Amount on hand July 1, 1872	14,997 25
Amount required for fiscal year ending June 30, 1874	100,000 00

(See Appendixes B 7 and *b* 7.)

8. *Black Lake Harbor, Michigan.*—During the last season 640 feet of pile-revetment were completed, 320 feet on each side of the cut inward from the ends of the old piers. The superstructure of 100 feet of crib-work at the inner end of the south pier, which was begun in 1870, was finished, and also the pier-head crib to the north pier. A protection of piles was constructed around the north pier.

Some damage has been done by the sea and by ice to the head of the north pier, but no expensive repairs are necessary. In other parts the work remains in good condition.

During the present season the channel will be dredged, and 400 feet of revetment of the cut finished. Four hundred and fifty feet of revetment will remain to be done to complete the improvement.

The former estimate for this work is deemed insufficient, as dredging will be found from time to time indispensable.

There will be needed $7,000 to complete the revetment of cut and $5,000 for dredging and contingencies. Total, $12,000.

Amount available July 1, 1871	$8,186 28
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	8,186 28
Amount available July 1, 1872	10,000 00
Amount required for fiscal year ending June 30, 1874	12,000 00

(See Appendixes B 8 and *b* 8.)

9. *Saugatuck Harbor, Michigan.*—During the last season 365 feet of pile-revetment was finished. Some refilling of the old revetment was found necessary.

Since June 13, 1872, the work of revetting with piles the south slab pier has been continued. The funds are sufficient for its completion. This work has proved to be much more costly than was originally estimated. Nothing has been done on the north side.

The recommendations (see report of Chief of Engineers, 1871,) for a north pier and revetment, to cost $59,300.98, are renewed.

Amount available July 1, 1871	$14,736 32
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during fiscal year ending June 30, 1872	10,553 20
Amount on hand July 1, 1872	19,183 12
Amount required for fiscal year ending June 30, 1874	25,000 00

See Appendixes B 9 and *b* 9.)

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10. *South Haven Harbor, Michigan.*—During the last season three cribs, 50 by 32 feet in plan, were sunk, one on the south and two on the north pier.

In the month of September the United States tug and dredge were sent to this harbor, but owing to the lateness of the season little work could be done. During the winter the dredge was drawn out and repaired. A large amount of stone was lost from the new cribs, and some refilling may be necessary.

The work of dredging the harbor has continued, and this season the crib that was removed from the north pier during the winter will be replaced, and one additional crib added thereto.

To complete the work of this harbor, as designed and recommended in former years, will require—

For pier-extension	$55,000 00
For dredging and removing slabs	32,000 00
For building revetment	12,138 33
Total	99,138 33

Amount available July 1, 1871	$16,476 00
Amount appropriated by act of June 10, 1872	12,000 00
Amount expended during fiscal year ending June 30, 1872	16,606 45
Amount available July 1, 1872	11,869 55
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendixes B 10 and *b* 10.)

11. *Saint Joseph Harbor, Michigan.*—During the last season the south pier was extended 416 feet by contract, and some crib-work put in at slight cost. There is considerable refilling necessary on both the north and south piers, and some slight repairs. This season these repairs will be put on the piers, and they will be well ballasted with stone.

Amount available July 1, 1871	$19,931 27
Amount appropriated by act of June 10, 1872	3,000 00
Amount expended during fiscal year ending June 30, 1872	19,772 38
Amount available July 1, 1872	3,158 89

(See Appendixes B 11 and *b* 11.)

IMPROVEMENT OF SAINT MARY'S FALLS CANAL AND SAINT MARY'S RIVER.—HARBORS ON LAKE HURON.—SAINT CLAIR FLATS CANAL.

Officer in charge, Major O. M. Poe, Corps of Engineers.

1. *Saint Mary's Falls Canal and Saint Mary's River.*—The efforts pending at the close of the last fiscal year for the acquirement of the additional lands required in the enlargement of the canal through the State of Michigan were unsuccessful; the only alternative remaining being a direct purchase from the individual owners at prices largely in excess of the real value of the property. Negotiations with this end in view are now in progress under the charge of the United States district attorney of the eastern district of Michigan.

The contract, covering the appropriation of $150,000 made by the act of July 11, 1870, was completed during the year and closed.

A contract was awarded, after due advertisement, to the contractors then engaged upon the work, for the expenditure of the appropriation, of $250,000 of March 3, 1871, in continuing the enlargement of the canal and building a revetment of timber and ballast-stone.

The expenditure of the first appropriation included the removal and rebuilding of the guard-lock.

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Operations during the year embraced the excavation of 17,741.16 cubic yards of rock; 26,839.40 cubic yards of gravel. In addition, 57,681.11 cubic feet of revetment, estimated as revetting-wall, was placed in the work, and the guard-gates rebuilt.

The act of Congress approved June 10, 1872, appropriated the further sum of $300,000, with a proviso that $15,000 of the same might be expended in securing the desired right of way. It is proposed to expend this amount (except the $15,000 referred to) toward the construction of the new lock, the plans for which are nearly completed. The letting of the work under this appropriation cannot be accomplished until the title to the additional lands required shall have received the approval of the Attorney-General of the United States, as provided by law.

Amount available July 1, 1871	$391,681 59
Amount appropriated by act of June 10, 1872	300,000 00
Amount expended during fiscal year ending June 30, 1872	99,469 36
Amount available July 1, 1872	592,212 23
Amount required for the fiscal year ending June 30, 1874	600,000 00

(See Appendix C 1.)

2. *Cheboygan Harbor, Michigan.*—Under the appropriation of March 3, 1871, a contract was made for the dredging, and operations were commenced during the month of August, 1871, and continued, with but little interruption, to about the middle of November, at which time 32,000 cubic yards of material had been removed, and the appropriation exhausted. The work done was the excavation of a channel from the 9-foot curve outside to the same depth inside the bar, of 9 feet in depth, 50 feet in width on the bottom, with side slopes of 1 to 1½. The present condition of this work is essentially the same as when completed last fall.

It is proposed to expend the appropriation of $15,000, approved June 10, 1872, toward making a 12-foot channel across the bar. With this end in view an appropriation of $35,000 is recommended.

Amount appropriated March 3, 1871	$10,000 00
Amount appropriated June 10, 1872	15,000 00
Amount expended during the year ending June 30, 1872	9,990 68
Amount available July 1, 1872	15,009 32
Amount required for fiscal year ending June 30, 1874	35,000 00

(See Appendix C 2.)

3. *Improvement of Au Sable River, Michigan.*—A contract was made, under the appropriation of March 3, 1871, for the superstructure of the south pier, which was carried up to a height of five timbers (5 feet) from the angle outward to the end of the pier. From the angle inward it was made only four timbers high, when, after furnishing all the lumber and iron, and doing a considerable portion of the work, the contractor failed to carry out his contract. This necessitated the purchase in open market of sufficient ballast-stone to render the work secure. The bar near the outer end of the piers extended much more rapidly into the lake during the year just past than formerly.

An extension of the north pier (except the superstructure) is proposed under the appropriation of June 10, 1872, chiefly as an experiment. It may prove to be cheaper to dredge a channel across the bar annually than to extend the piers further, and an estimate is made with this in view. No estimate is made for completing the work, but an appropriation of $20,000 is recommended to be expended in such manner as the experience of the current year may indicate as most judicious.

Amount available July 1, 1871	$10,000 64
Amount appropriated by act of June 10, 1872	10,000 00

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Amount expended during fiscal year ending June 30, 1872	$7,415 42
Amount available July 1, 1872	12,585 22
Amount required for fiscal year ending June 30, 1874	20,000 00

(See Appendix C 3.)

4. *Improvement of Saginaw River, Michigan.*—A small balance of an appropriation available for this improvement was expended during the year in making a survey to determine the condition of the work. This survey indicates that no change has taken place, and that the improvement continues to subserve a valuable purpose.

No appropriation is recommended for the next fiscal year.

(See Appendix C 4.)

5. *Harbor of Refuge on Lake Huron.*—A board of engineers was convened last fall to decide upon a proper location for the proposed harbor to which were submitted the results of the surveys and examinations previously made under the appropriation of March 3, 1871. Although Port Hope had been recommended as the point possessing the greatest advantages for the harbor, the board recommended further examinations to be made within certain prescribed limits. These examinations were made, and the board convened, but were still unable to decide upon a location, and recommended the continuance of examinations to the southward, and until a point was reached where the rock formation disappears, provided this distance should not be found to exceed about forty miles from Point Aux Barques light-house. These examinations were resumed at once, and have been completed, and at the date of the report the board has been reconvened, and the results of the examinations submitted to it.

Amount available July 1, 1871	$97,013 31
Amount appropriated by act of June 10, 1872	100,000 00
Amount expended during the fiscal year ending June 30, 1872	7,193 47
Amount available July 1, 1872	189,819 84

As the work will be put under contract as soon as the site is selected, an appropriation is recommended, for the next fiscal year, of $100,000.

(See Appendixes C 5 and C 8.)

6. *Clinton River, Michigan.*—The appropriation of March 3, 1871, was expended during the year, as proposed in the last annual report, in making a survey of the improvement, to determine its condition and requirements. The results of this survey indicated only a little more than 6 feet of water on the shoalest part of the bar, at a point where, as throughout the channel, the depth was made 9 feet under the appropriation of July 11, 1870. As an experiment, a curved channel is suggested, to be protected by plantations of wild rice, the cost of which is estimated at $8,000, though no appropriation for this purpose is recommended.

Amount available July 1, 1871	$1,500 00
Amount expended during the fiscal year ending June 30, 1872	1,489 25
Amount available July 1, 1872	10 75

(See Appendix C 6.)

7. *Saint Clair Flats Canal.*—The embankments of this work have been repaired, as they required it, during the year, by the use of marsh sods. This method thus far has proven quite efficient, but is expensive, though the cheapest that has yet been devised.

The depth of the canal was, at the close of the fiscal year, essentially the same as when the work was completed. A deposit, however, is being made at a distance of about 1,000 feet below the lower end of the canal, and there is now more water in the canal than on the

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bar thus formed. As a remedy for this evil, the dredging of a channel is recommended by the officer in charge, and an appropriation of $80,000 is asked for the purpose.

It is also proposed to continue the system of stopping, with sods, whatever leaks appear in the sheet-piling, and of refilling the holes in the embankment behind them with earth. For this purpose, and for the services of the custodian of the canal, the additional sum of $5,000 is recommended for the next fiscal year.

Amount available December 11, 1871, the date of the transfer of the work to Major Poe	$2,662 16
Appropriation of March 3, 1871	1,500 00
Appropriation of June 10, 1872	4,000 00
Expended to July 1, 1872	2,205 16
Amount available July 1, 1872	5,957 00
Amount required for the fiscal year 1873–'74	85,000 00

Since the preparation of this portion of the annual report, a communication has been received from the officer in charge, under date of October 3, urging that the full amount of his estimate for this work be appropriated, and stating that since making his annual report the depth in the canal has been practically reduced to 11 feet 6 inches, principally by the action of the wheels of heavily-laden propellers. This difficulty can be obviated by increasing the depth of the canal, as recommended in the report from this office of January 9, 1872, on Senate bill No. 345, "for deepening Saint Clair Flats Canal to 16 feet." The amount estimated for this purpose was $40,000, which sum, in addition to that of $85,000, is recommended to be appropriated, making the total required $125,000. The estimate for this work submitted through the Treasury Department was $85,000. It should be increased as here indicated.

(See Appendix C 9.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Poe has been charged with the following surveys and examinations directed to be made by the act of June 10, 1872, viz:

1. *At mouth of Pine River, Michigan.*
2. *At Port Austin, Michigan.*
3. *At Port Crescent, Michigan.*

HARBORS ON LAKE ERIE, WEST OF DUNKIRK.

Officer in charge, Major George L. Gillespie, Corps of Engineers.

1. *Monroe Harbor, Michigan.*—No work was done here during the year. The appropriation of $10,000 by act of Congress, approved June 10, 1872, will be expended in deepening channel, repairing revetment of United States ship-canal, and in closing old channel-bed near the head of United States ship-canal.

Amount available July 1, 1871	$139 05
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during the year ending June 30, 1872	136 84
Amount available July 1, 1872	10,002 21
Amount required for fiscal year ending June 30, 1874	1,000 00

(See Appendix D 1.)

2. *Harbor of Toledo, Maumee Bay, Ohio.*—Under existing contracts, 332,791 cubic yards of material have been removed by dredging from the southwest channel through Maumee Bay. The improved channel is generally 120 feet wide, with 14 feet of water at low stage.

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Amount available July 1, 1871	$104,053 64
Amount appropriated by act of June 10, 1872	15,000 00
	119,053 64
Amount expended during the year ending June 30, 1872	84,276 33
Amount available July 1, 1872	34,777 31
Amount required for fiscal year ending June 30, 1874, to complete improvement	30,000 00

(See Appendix D 2.)

3. *Maumee River, Ohio.*—The appropriation, June 10, 1872, of $10,000, will be expended in cutting a 60-foot channel, giving 8 feet water at ordinary stage, between Maumee City, Ohio, and Perrysburgh, Ohio, and in deepening existing channel over Delaware Flats.

(See Appendix D 3.)

4. *Sandusky River, Ohio.*—The appropriation, approved June 10, 1872, of $10,000, will be expended in cutting a 60-foot channel, giving 9 feet water from Fremont, Ohio, to the mouth of the river.

Amount available July 1, 1871	$347 36
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	78 34
Amount available July 1, 1872	10,269 02

(See Appendix D 4.)

5. *Sandusky City Harbor, Ohio.*—Thirty thousand seven hundred and eighty-four cubic yards sand and clay have been removed by dredging from inner channel during the year.

The appropriation of June 10, 1872, will be expended either in cutting a new inner channel through the shoal in the bay, or in improving the west channel.

Amount available July 1, 1871	$9,433 67
Amount appropriated by act of June 10, 1872	13,000 00
Amount expended during the fiscal year ending June 30, 1872	9,354 94
Amount available July 1, 1872	13,078 73

A supplementary report will be made, giving the amount required to complete the improvement.

(See Appendix D 5.)

6. *Huron Harbor, Ohio.*—No work of improvement or repair was done during the year. A few repairs will be made to piers during the season.

Amount available July 1, 1871	$9,406 35
Amount expended during the fiscal year ending June 30, 1872	425 28
Amount available July 1, 1872	8,981 07

(See Appendix D 6.)

7. *Vermillion Harbor, Ohio.*—No improvement or repairs were made during the season. The existing appropriation of $5,000 will be expended in deepening the channel across the outer bar, and on the inside, by blasting and dredging.

Appropriation of $25,000 is recommended for the extension of piers in the aggregate 400 feet.

Amount available July 1, 1871	$10 27
Amount appropriated by act of June 10, 1872	5,000 00
Amount available July 1, 1872	5,010 27
Amount required for fiscal year ending June 30, 1874	25,000 00

(See Appendix D 7.)

8. *Black River Harbor, Ohio.*—No work of improvement or repair was carried on during the year.

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The appropriation of $20,000 by act approved June 10, 1872, will be expended in repairing and extending piers, and in dredging.

Amount available July 1, 1871	$7,910 27
Amount appropriated by act of June 10, 1872	20,000 00
Amount expended during fiscal year ending June 30, 1872	635 15
Amount available July 1, 1872	27,275 12

(See Appendixes D 8 and D 17.)

9. *Cleveland Harbor, Ohio.*—Sixty-five thousand six hundred and sixty-four cubic yards of material were removed from the channel between the piers, and both piers were repaired during the year.

Amount available July 1, 1871		$19,682 75
Allotted during the year for repairs		1,000 00
Amount expended during the fiscal year ending June 30, 1872	$20,319 52	
Part of allotment returned to Treasury June 30, 1872	363 23	
		20,682 75
Amount required for fiscal year ending June 30, 1874, for repairs		1,000 00

(See Appendix D 9.)

10. *Grand River Harbor, Ohio.*—Both piers were repaired by days' labor, and are being extended in the aggregate 900 feet, under contract dated May 16, 1872.

Amount available July 1, 1871	$61,121 83
Amount expended during the fiscal year ending June 30, 1872	3,999 29
Amount available July 1, 1872	57,122 54

(See Appendixes D 10 and D 18, 19, 20, and 21.)

11. *Ashtabula Harbor, Ohio.*—During the past season 4,505 cubic yards of solid rock were blasted and removed, and 3,436 cubic yards loose rock and sand were dredged from the channel between the piers, on the inside.

The improvement in progress will be continued under the new appropriation.

Amount available July 1, 1871	$15,566 27
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during the fiscal year ending June 30, 1872	12,631 54
Amount available July 1, 1872	17,934 73
Amount required for fiscal year ending June 30, 1874, for repairs	800 00

(See Appendix D 11.)

12. *Conneaut Harbor, Ohio.*—The east pier has been extended 90 feet during the year. No further appropriation is required.

Amount available July 1, 1871	$6,282 72
Amount expended during the fiscal year ending June 30, 1872	6,282 72
Amount required for fiscal year ending June 30, 1874, for repairs	400 00

(See Appendix D 12.)

13. *Erie Harbor, Pennsylvania.*—The north pier has been extended eastwardly 120 feet. Sixty-three thousand eight hundred and seventy-seven cubic yards sand were removed, by dredging, from the inner and the outer bars. The north and south piers were put in thorough repair. Fifty-one thousand three hundred assorted trees and roots have been planted on the neck of the peninsula; and the north shore of the peninsula has been protected by brush-work and stone, and the east shore by riprap work.

Amount available July 1, 1871	$42,851 35
Alloted for peninsula	6,080 00
Amount appropriated by act of June 10, 1872	15,000 00

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Amount expended during the fiscal year ending June 30, 1872	$44,474 62
Amount available July 1, 1872	19,456 73

(See Appendix D 13.)

14. *Port Clinton Harbor, Ohio.*—The appropriation, June 10, 1872, of $8,000, will be expended in deepening the entrance to Portage River, and in protecting the peninsula on the north side of entrance.

Amount appropriated by act of June 10, 1872	$8,000 00

(See Appendix D 14.)

15. *Rocky River, Ohio.*—The appropriation, June 10, 1872, of $10,000, will be expended in making an east pier, in running a double row of piles across the west end of the sand beach, and in dredging.

No additional appropriation is recommended.

Appropriation June 10, 1872	$10,000 00

(See Appendix D 15.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

In compliance with the provisions of the act of March 3, 1871, a survey was made, under the direction of Major Gillespie, of Maumee River, above Toledo, and a report thereon transmitted to Congress December 21, 1871.

(See Appendix D 16.)

HARBORS ON LAKE ERIE, EAST OF ERIE, PENNSYLVANIA.

Officer in charge, Major F. Harwood, Corps of Engineers.

1. *Dunkirk Harbor, New York.*—During the fiscal year 210 feet of breakwater were built, and dredging commenced on the channel and its approaches, and finished September 1, 1872.

During the fiscal year 1872–'73, 150 feet of breakwater will be added, making the work 360 feet long at the close of that fiscal year.

A thorough resurvey has been made of the harbor.

Amount available July 1, 1871	$24,862 77
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during the fiscal year ending June 30, 1872	24,639 69
Amount available July 1, 1872	25,223 08
Amount required for fiscal year ending June 30, 1874	150,000 00

(See Appendix E.)

2. *Buffalo Harbor, New York.*—The north United States pier-head and other completed works have been repaired and secured during the year.

To the breakwater there has been added 425 feet in cribs, partly covered by superstructure. At the close of the working season, 2,084 feet of breakwater will probably be completed, and at the close of the fiscal year, June 30, 1873, probably 2,387 feet.

Amount available July 1, 1871	$70,056 28
Amount appropriated by act of June 10, 1872	75,000 00
Amount unexpended balance heretofore appropriated for Buffalo sea-wall	23,485 04
	168,541 32
Amount expended during fiscal year ending June 30, 1872	70,027 65
Amount available July 1, 1872	98,513 67
Amount required for fiscal year ending June 30, 1874	410,000 00

(See Appendix E.)

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HARBORS ON LAKE ONTARIO AND THE RIVER SAINT LAWRENCE.

Officer in charge, Major John M. Wilson, Corps of Engineers.

1. *Olcott Harbor, mouth of Eighteen-mile Creek, New York.*—Operations have been carried on under contract during the year; 140 feet of crib-work has been added to the east, and 90 feet to the west pier, the superstructure having been completed for a distance of 215 feet on the east, and 236 feet on the west pier. During the present working season it is proposed to add 120 linear feet of crib-work to each pier.

The survey of the harbor has developed an underlying bed of rock, the removal of a portion of which, to make a proper channel, will increase the former estimate of the final cost of completing the harbor.

Amount available July 1, 1871	$5,490 97
Amount expended during the fiscal year ending June 30, 1872	5,490 97
Amount appropriated by act of June 10, 1872, and available July 1, 1872	10,000 00
Amount required for the fiscal year ending June 30, 1874, to complete the harbor	50,000 00

(See Appendix F 1.)

2. *Oak Orchard Harbor, New York.*—During the fiscal year the piers have been extended as far as is deemed necessary at present; 150 feet of crib-work has been added to the east, and 120 feet to the west pier, the superstructure having been completed for a distance of 340 feet on the one, and 269 feet on the other.

Eight thousand four hundred and seventeen eight-tenths cubic yards of stiff clay, mingled with cobble-stones, &c., have been removed from the channel between the piers. During the present season it is proposed to excavate all the material, except rock, from the channel between the piers, to a depth of 12 feet at mean low water. A bed of red sand-stone has been found to exist between the piers, which will necessitate the removal of 7,834 cubic yards of rock in order to obtain a proper channel.

Amount available July 1, 1871	$15,724 37
Amount appropriated by act of June 10, 1872	2,500 00
Amount expended during the fiscal year ending June 30, 1872	9,484 39
Amount available July 1, 1872	8,739 98
Amount required for fiscal year ending June 30, 1874	30,000 00

(See Appendix F 2.)

3. *Charlotte Harbor, mouth of Genesee River, New York.*—During the season 1871, operations were restricted to such minor repairs as the condition of the piers demanded.

In April, 1872, operations were commenced under contract, and by June 30, 1872, 90 feet of new superstructure was completed, and 90 additional feet partially completed.

During the present season it is proposed to remove the old superstructure from 700 feet of the west pier, and to replace it with new materials.

Amount available July 1, 1871	$12,858 33
Amount received for sale of timber to Pultneyville Harbor	666 40
Amount expended during the fiscal year ending June 30, 1872	2,196 08
Amount available July 1, 1872	11,328 65

(See Appendix F 3.)

4. *Pultneyville Harbor, New York.*—A breakwater, extending from the west shore, 180 feet long, consisting of six cribs, 30 feet by 20 feet, of an average height of 9½ feet, with a superstructure 4 feet high, has been completed.

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During the present season it is proposed to construct about 210 feet of the east pier, for the protection of vessels during an easterly or a northeasterly gale.

Amount available July 1, 1871	$8,976 49
Amount expended during the fiscal year ending June 30, 1872	8,976 49
Amount appropriated by act of June 10, 1872, and available July 1, 1872	10,000 00
Amount required for the fiscal year ending June 30, 1874	31,500 00

(See Appendix F 4.)

5. *Big Sodus Bay, New York.*—No appropriation having been made for the fiscal year, no work was done except to make a careful survey of the harbor.

During the present season it is proposed to commence dredging a channel between the piers, and to repair the east breakwater.

Amount available July 1, 1871	$1,224 18
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during the fiscal year ending June 30, 1872	41 67
Amount available July 1, 1872	16,182 51
Amount required for fiscal year ending June 30, 1874	30,000 00

(See Appendix F 5.)

6. *Harbor of Little Sodus, New York.* — During the fiscal year the west pier has been leveled up, and replanked for a distance of 350 feet; a pier-head 30 feet square, for a beacon-light, constructed at its outer end, and the breakwater connecting it with the west shore entirely rebuilt for a distance of 250 feet, and partially rebuilt for a distance of 90 feet. A channel, parallel to the pier, 1,200 feet long, 200 feet wide, and 12 feet deep at mean low water, has been excavated.

During the present season it is proposed to construct 420 feet of an east pier parallel to, and 250 feet from, the west one.

Amount available July 1, 1871	$15,352 19
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during the fiscal year ending June 30, 1872	12,603 58
Amount available July 1, 1872	17,748 61
Amount required for the fiscal year ending June 30, 1874	45,000 00

(See Appendix F 6.)

7. *Harbor of Oswego, New York.*—Operations during the fiscal year have been carried on by contract, by hired labor, and by purchase of materials in open market.

The old pier has been put in good condition and strengthened by two counterparts in rear of it; a short breakwater has been placed in the angle, near the light-house, for the protection of the latter.

Operations upon the new breakwater were commenced July 5, 1871, and during the year, 1,059 feet of crib-work were sunk, upon which 640 feet of superstructure were completed. During the present fiscal year it is proposed to continue operations upon the new breakwater, by building 600 feet of crib-work in an average depth of 24 feet.

Amount available July 1, 1871	$126,179 01
Amount appropriated by act of June 10, 1872	100,000 00
Amount expended during the fiscal year ending June 30, 1872	82,851 06
Amount available July 1, 1872	143,327 95
Amount required for the fiscal year ending June 30, 1874	300,000 00

(See Appendixes F 7 and F 9.)

8. *Harbor of Ogdensburgh, New York.*—During the year dredging has been carried on in the Oswegatchie River and in the Saint Lawrence, in the channel parallel to the docks.

The dredging of the hard portion of the Saint Lawrence channel,

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west of the Prescott ferry, has been completed by removing 23,293 cubic yards; the dredging of the remainder of this channel has been continued, and 50,376 cubic yards have been removed. During the present working season it is proposed to do a small amount of dredging in the Oswegatchie, and to continue work upon the Saint Lawrence channel.

Amount available July 1, 1871	$24,754 76
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during the fiscal year ending June 30, 1872	12,003 78
Amount available July 1, 1872	22,750 98
Amount required for fiscal year ending June 30, 1874	6,000 00

(See Appendix F 8.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Wilson has been charged with the following surveys and examinations, directed to be made by the act of June 10, 1872:

1. At Bear Creek, Lake Ontario, New York.
2. At Waddington Harbor, New York.

HARBORS ON LAKE CHAMPLAIN.—SURVEY AND IMPROVEMENT OF OTTER CREEK, VERMONT.

Officer in charge, Lieutenant-Colonel John Newton, Corps of Engineers.

1. *Plattsburg Harbor, New York.*—During the year the superstructure of the extension, of 94 feet in length, commenced the previous season, was completed.

The crib-work of the extension, of 150 feet in length, commenced in June, 1871, was completed and sunk in position in the month of July, 1871, and work on the superstructure was commenced in the month of September, 1871; but, owing to unfavorable winds, the work was suspended, and at the close of the year remains unfinished. Under appropriation for this harbor, of June 10, 1872, it is proposed to continue the extension in a northeasterly direction for 75 feet.

To complete the extension of the breakwater about 80 feet further, which is all that is needed, and for the repairs of the southern end of the breakwater, an additional appropriation of $15,000 for the fiscal year ending June 30, 1874, is asked.

Amount available July 1, 1871	$19,904 38
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	13,082 21
Amount available July 1, 1872	16,822 17
Amount required for fiscal year ending June 30, 1874	15,000 00

(See Appendix G 1.)

2. *Burlington Harbor, Vermont.*—During the year the superstructure of the extension, of 171 feet, commenced the previous season, was completed.

The crib-work of the extension of 217 feet in length in a southerly direction, commenced in June, 1871, was completed, the cribs having been sunk in position, one in September and the other in October, and work on the superstructure was commenced in February last and finished in June.

Under appropriation for this harbor, of June 10, 1872, it is proposed to continue the extension in a southerly direction for 180 feet.

The extension of this breakwater from both extremities is necessary, in order to give shelter at the wharves of the city, which have been much extended.

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Amount asked for the fiscal year ending June 30, 1874, $30,000, is deemed moderate, considering the necessities of the case.

Amount available July 1, 1871		$46,429 85
Amount appropriated by act of June 10, 1872		30,000 00
		76,429 85
Amount covered into Treasury (appropriation Burlington breakwater) by war-surplus fund No. 130, dated June 29, 1872	$6,669 13	
Amount expended during fiscal year ending June 30, 1872	33,826 97	
		40,496 10
Amount available July 1, 1872		35,933 75
Amount desired for fiscal year ending June 30, 1874		$30,000 00

(See Appendix G 2.)

3. *Survey and improvement of Otter Creek, Vermont.*—In compliance with the act of March 3, 1871, a survey was made of Otter Creek, from Vergennes to its outlet on Lake Champlain, under the direction of Lieutenant-Colonel Newton, and three estimates presented for the improvement of the navigation to Vergennes; first, by dredging only, 51,000; secondly, a more complete project, by the addition of crib or pile work, with the object of narrowing the channel and securing a more permanent improvement, $106,842; and thirdly, a modification of this by the omission of works of only probable necessity, or of such as may be postponed for the present, $58,146. This last project has been adopted, being deemed sufficient for a material and probably permanent improvement of the navigation.

The amount of $10,000 appropriated by the act of June 10, 1872, will be applied to dredging upon the shoals in the creek.

Amount required for the next fiscal year, $48,146.

(See Appendix G 3.)

CONSTRUCTION OF THE ROCK ISLAND BRIDGE—PRESERVATION OF THE FALLS OF SAINT ANTHONY—IMPROVEMENT OF THE MINNESOTA, UPPER MISSISSIPPI, AND ILLINOIS RIVERS, AND OF THE DES MOINES AND ROCK ISLAND RAPIDS.

Officer in charge, Colonel John N. Macomb, Corps of Engineers, having under his immediate orders Captains W. H. H. Benyaurd, A. H. Burnham, and A. Stickney, Corps of Engineers.

1. *Rock Island bridge.*—During the past year this work has been completed, and the officer in charge has accepted the superstructure from the contractors. There remained at the close of the fiscal year a small amount of work to be done upon the wagon-road approaches, and the deepening of that portion of the channel which lies between the draw-pier and the island, which will be finished before the close of the working season.

Amount available July 1, 1871	$729,087 85
Amount expended during fiscal year ending June 30, 1872	586,140 39
Amount available July 1, 1872	142,947 46
Of which there will be required during current fiscal year, for completing wagon-road, approaches, &c., about	42,947 46

(See Appendixes H 1, H 9, H 10, and H 11.)

2. *Preservation of the Falls of Saint Anthony.*—But little actual progress has been made toward the completion of this work during the past fiscal year, an accurate survey having demonstrated the necessity of much more extensive works than had been contemplated. The major part of

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the funds expended during the fiscal year have been used in repairing and preserving from destruction the works already existing.

The lining of the tunnel has been continued chiefly under the auspices of the "Union Committee" of Minneapolis, and $35,000 of the appropriation for the current year has been set aside to be used for this purpose.

The board of engineers called to investigate the subject recommend an appropriation of $200,000 for effecting the preservation of the falls, and improving the river above the same.

Amount available July 1, 1871	$38,574 17
Expended during the fiscal year ending June 30, 1872	36,153 64
Appropriated by act of June 10, 1872	50,000 00
Available July 1, 1872	52,420 53
Required for fiscal year ending June 30, 1874	200,000 00

(See Appendixes H 2, H 12, H 13, and H 14.)

3. *Improving Minnesota River.*—The work during the past fiscal year has been confined to the removal of bowlders between the mouth of the Yellow Medicine River and Fort Ridgely, a distance of seventy miles, and the inspector reports the channel clear of bowlders between these points. The work was done under contract.

Amount available July 1, 1871	$10,233 91
Amount expended during fiscal year ending June 30, 1872	10,016 51
Amount appropriated by act of June 10, 1872	10,000 00
Amount available July 1, 1872	10,217 40
Amount required for fiscal year ending June 30, 1874	20,000 00

(See Appendixes H 3 and H 15.)

4. *Improving the Upper Mississippi River.*—The steamers Montana and Caffrey have rendered excellent service in keeping a clear channel between the Upper Rapids and Saint Paul. Although the season was one of unusually low water, the boats were able during the greater portion of the time to keep from 3 to 3½ feet of water on most of the bars, besides removing numerous snags, &c. The Caffrey's capabilities were limited, owing to her too great draught, she being old and water-logged, and it is desirable to build a new hull of very light draught to receive the Caffrey's machinery.

Amount available July 1, 1871	$45,064 14
Expended during fiscal year ending June 30, 1872	44,019 46
Appropriated by act of June 10, 1872, under head of "dredge and snag-boats on Mississippi River"	42,000 00
Amount available July 1, 1872	43,044 68
Required for fiscal year ending June 30, 1874	72,000 00

Of which $30,000 is for a new steamer to replace the Caffrey, and the balance to meet the current expenses of the two steamers during the year.

(See Appendixes H 4 and H 16.)

5. *Improving the Illinois River.*—The work upon the Illinois River improvement is fully set forth in the report of Colonel Macomb's assistant in the operations, by which it will be seen that the amount available at the beginning of the last fiscal year, $73,729.90, has been expended chiefly under a contract for work upon the lower portion of the river. There being no funds for the continuance of the work, the engineer force has been discharged or transferred. An annual appropriation of $12,000 is recommended for maintenance of the improved channel, and an estimate is presented, for the completion of the improvement from Henry to the mouth of the river, amounting to $350,000,

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including the work necessary to restore those portions of the excavated channel where there has been shoaling.

Required for fiscal year ending June 30, 1874, $150,000.

(See Appendixes H 5 and H 17.)

6. *Improving the Des Moines Rapids.*—During the past fiscal year work has been done on the lower and middle locks, and on the prism of the canal.

Lower lock.—The construction of this lock was pushed on with great vigor as long as the funds available would allow, both the weather and stage of water being favorable, not only to progress, but to the execution of superior workmanship.

Middle lock.—Work ceased on this lock September 9, 1871, from want of funds.

Section-work.—Only one month's work was done upon this portion of the canal, during July, 1871, owing to want of funds. A good deal of time was taken up in closing leaks in the embankment, which hindered the progress of construction and threatened the safety of the portion constructed. During the fall of 1871, a careful resurvey and remeasurement of the improvement were made, the results of which confirmed the accuracy of former surveys.

Amount on hand at commencement of fiscal year ending June 30, 1872 ..	$400,000 00
Expended during fiscal year ending June 30, 1872	288,843 41
Expended by authority, toward close of fiscal year ending June 30, 1871.	110,944 06
Amount appropriated by act of June 10, 1872	400,000 00
Amount available July 1, 1872	400,212 53
Balance required over previous appropriations to complete the work	1,323,481 19

Of which the sum of $1,000,000 could be advantageously used during the fiscal year ending June 30, 1874.

(See Appendixes H 6 and H 18.)

The cost of the construction of the Des Moines Rapids Canal has materially exceeded the original estimate of the officer in charge and of the board of officers that revised the project. The causes of this increase are stated in the joint reports of Colonel Macomb, now in charge of the work, and Major-General J. H. Wilson, formerly in charge.

(See Appendixes H 19 and H 20.)

7. *Improving the Rock Island Rapids.*—During the fiscal year the work has been carried on under contract. The improvements have been completed at the opening of Smith's Chain, at Smith's Chain, at the patches between Sycamore and Smith's Chains, and at Crab Island, and the work at Saint Louis Chain is in an advanced state of progress, and will be completed during the present working season.

It is contemplated before the close of navigation to improve the channel at Winnebago Island, and to remove certain patches between Saint Louis and Campbell's Chains, as well as others between Campbell's Chain and Winnebago Island. Proposals for this work have already been invited under the appropriation of June 10, 1872, which being completed, the improvement will be finished from the head of the rapids to the head of Duck Creek Chain.

There will remain, for completing the entire improvement, about 9,000 cubic yards of rock to be removed at the Lower Chain, at the foot of Moline Chain, and at the head of Duck Creek Chain, for the accomplishment of which, and meeting all probable contingencies in closing the work, the officer in charge asks for an appropriation of $108,000.

Amount appropriated by act of July 11, 1870	$150,000 00
Amount appropriated by act of March 3, 1871	150,000 00

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Amount appropriated by act of June 10, 1872	$50,000 00
Amount expended during fiscal year ending June 30, 1872	191,513 29
Amount available July 1, 1872	130,197 43
Amount required for fiscal year ending June 30, 1874	108,000 00

(See Appendixes H 7, H 21; and H 22.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

The work under this head, during the fiscal year, consisted of a survey of a few miles of the Mississippi River immediately above the Falls of Saint Anthony, of an examination of the bridge over the Saint Croix River at Hudson, and a reconnoissance of the Chippewa River between Chippewa Falls and Eau Claire.

Colonel Macomb is charged with the following examinations and surveys, directed to be made by the act of June 10, 1872, viz:

1. *Of Chippewa River up to Chippewa Falls, Wisconsin.*

2. *Of Minnesota River above the mouth of the Yellow Medicine, Minnesota.*

IMPROVEMENT OF THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS, AND OF RIVERS IN THE STATES OF MISSOURI, ARKANSAS, AND LOUISIANA—IMPROVEMENT OF THE HARBORS OF SAINT LOUIS AND ALTON.

Officer in charge, Lieutenant-Colonel W. F. Raynolds, Corps of Engineers, who has under his immediate orders Major C. R. Suter and Captain C. J. Allen, Corps of Engineers.

The snag-boats have worked on the Missouri, from Omaha to the mouth; on the Mississippi, from Keokuk to Vicksburg; and on the Arkansas from Pine Bluff to the mouth; and, under other appropriations, on the White, Black, and Little Red Rivers, on the Saint Francis and on the Ouachita Rivers. They have removed 5,475 snags, (weighing 74,425 tons;) they have cut 25,829 trees; destroyed 92 rack-heaps; and run 21,782 miles.

Owing to the length of time the boats have been in service, the repairs consume a large part of the appropriation, and the engineer in charge urges the construction of new iron hulls.

Two boats worked for a time in the harbor of Saint Louis, removing wrecks and other obstructions.

Amount available July 1, 1871	$141,169 97
Amount appropriated by act of June 10, 1872	90,000 00
Amount expended during fiscal year ending June 30, 1872	118,961 38
Amount available July 1, 1872	112,208 59
Amount required for fiscal year ending June 30, 1874	600,000 00

(See Appendix I 1.)

2. *Improvement of Osage River, Missouri.*—The obstructions to navigation in this stream are numerous shoals having from 12 to 18 inches of water on them, the intermediate pools being deep. Some of the shoals were deepened by the use of scrapers, and 9,600 yards of material removed, at a cost of 25 cents per cubic yard. Work was done on two other shoals of harder material, after the water had risen, which cost 60 cents per cubic yard.

Considerable work was done in the way of rebuilding and extending wing-dams built several years ago by the State of Missouri. The work done afforded decided benefit to commerce during the extreme low water of last season.

It is proposed to continue the improvement during the present year by contract. Amount available July 1, 1871, $25,000.

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Amount appropriated by act of June 10, 1872	$25,000 00
Amount expended during the fiscal year ending June 30, 1872	8,215 49
Amount available July 1, 1872	41,784 51
Amount required for fiscal year ending June 30, 1874	150,000 00

(See Appendix I 2.)

3. *Improvement of White, Black, and Little Red Rivers, Arkansas.*—A snag-boat was sent into White River, and operated there and in the Little Red and Black Rivers, from the beginning of November last to the end of January, but, owing to the small depth of water, but little could be done in the smaller streams. The amount of work done was 543 snags removed, and 422 trees cut.

Amount available July 1, 1871	$10,000 00
Amount expended during the fiscal year	8,018 89
Amount available July 1, 1872	1,981 11

(See Appendix I 3.)

4. *Improvement of Saint Francis River, Arkansas.*—A snag-boat was sent into this stream in January, ascending as far as Cow Island, about thirty-seven miles from the mouth, when a sudden fall in the river prevented her proceeding further. Subsequently the snag-boat Thayer, of lighter draught, operated in the river during the month of April. The amount of work done by these two boats was 431 snags pulled and 151 trees cut.

The officer in charge renews his former recommendations for the construction of two snag-boats of light draught for operations in these small streams.

Amount available July 1, 1871	$10,000 00
Amount expended during the fiscal year ending June 30, 1872	10,000 00

(See Appendix I 4.)

5. *Improvement of Little Missouri River, Arkansas.*—The improvement of this stream was confined to the removal of snags from the channel and leaning trees from the banks, which was done by a party working on a flat-boat provided with requisite shears and hoisting-appliances. Work was performed from the junction with Ouachita, up to the mouth of Antoine Creek, the head of navigation. The appropriation only admitted removing the most serious obstructions.

It is proposed to re-organize the party and resume work the present season, and it is hoped that the amount available will complete the improvement in the manner proposed.

Amount available July 1, 1871	$10,000 00
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	8,445 06
Amount available July 1, 1872	11,554 49

(See Appendix I 5.)

6. *Improvement of the Ouachita River in Arkansas.*—This improvement consists in removing snags and cutting timber from the banks.

Two parties were engaged from July to December, and it is estimated fully half the obstructions have been removed.

A survey was made for lock and dam improvement as high up as Camden, and a report transmitted to Congress in April last and printed in Ex. Doc. H. R. No. 252. (See Appendix I.) It is proposed to employ the light-draught snag-boat in the stream the coming winter, and to purchase the timber for the foundations of the proposed locks.

Amount available July 1, 1871	$25,000 00
Amount appropriated by act of June 10, 1872	60,000 00
Amount expended during fiscal year ending June 30, 1872	24,002 73

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Amount available July 1, 1872	$60,997 27
Amount required for fiscal year ending June 30, 1874, to complete improvement with wooden locks	404,233 50

(See Appenpix I 6.)

7. *Improvement of the Ouachita River in Louisiana.*—The appropriation of $26,000 made by the act of Congress, approved March 3, 1871, has been expended in removing snags from the channel and overhanging trees from the banks. The dredge and snag-boat Octavia, the snag-boat R. E. De Russy, and the crane-boat Ouachita, purchased for this service, were employed on the work. The Octavia was employed from December 3, 1871, to February, 1872; the De Russy from January 8 to February 14, 1872; and the crane-boat from October 21 to December 16, 1871.

The proposed improvement by locks and dams from Trinity, Louisiana, to Camden, Arkansas, calls for three locks in Louisiana. The estimated cost of each, if locks are built of wood, is $232,616.75; if built of stone, $438,983.27.

It is proposed to expend a portion of the appropriation of $40,000 made by the last Congress in the removal, by the use of a snag-boat, of such obstructions as will be in the way, whatever plan of improvement is adopted, and in the purchase of the material for the foundation of one of the proposed locks.

Amount available July 1, 1871	$26,000 00
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during fiscal year ending June 30, 1872	25,135 02
Amount available July 1, 1872	40,864 98
Amount required for fiscal year ending June 30, 1874, (to complete improvement with wooden locks)	657,850 25

(See Appendix I 7.)

8. *Improvement of the Harbors of Saint Louis and Alton.*—The examinations and surveys "of Saint Louis and Alton Harbors, and of the Mississippi River between Alton and the mouth of the Maremec," directed to be made by the act of July 11, 1870, have been continued.

A report from Lieutenant-Colonel Raynolds and Captain Allen, Corps of Engineers, upon the propriety and cost of opening Cabaret Slough, and also a report from the same officers upon the present condition of the east bank of the Mississippi River opposite the mouth of the Missouri, which had been represented to this office as having been eroded to a serious extent, will be found in Appendixes I 8 and I 9.

A board of engineer officers was constituted to examine and report upon the present condition of the Mississippi River between Saint Louis and Alton, with a view to the preparation of plans for the improvement and maintenance of those harbors, and for the prevention of the erosion of the river-banks.

The conclusions arrived at by the board, which may be stated in general terms as follows, have been approved.

1. They propose to close the channel west of Ellis Island, so as to throw all the water through the eastern or harbor-channel at Alton; this is to be done by a high or low dike, as may be determined upon.

2. The board do not believe that there are valid grounds for apprehending that the Mississippi will change its course so as to flow into the valley of Long Lake, or will form any considerable channel through it.

3. The proposition to prevent, or at least lessen, the erosion opposite the mouth of the Missouri, by re-opening Mobile Chute, is worthy of consideration, and they recommend that the snags and other obstruc-

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tions which now obstruct the flow of water through that channel be removed.

4. They prefer to protect the banks in Sawyer's Bend by revetment rather than to adopt the plan of deflecting a portion or all of the volume of discharge through Cabaret Slough.

5. They are of opinion that the river, throughout the entire length of the city-front of Saint Louis, should, and will eventually, be made to flow in a permanent channel; and that the eastern bank of the river will have to be brought to a line parallel, or nearly so, to the opposite city-levee, at a distance from it at low water of not over 1,200 or 1,500 feet, and rendered permanent. The present demands are that from Bischoff's Dike down to the East Saint Louis levee, the channel should be confined within the above limit. To do this they recommend the raising and extension of the two Venice dikes and the long dike; and they believe that, when these dikes shall have been built as proposed, the demands of business will soon cause the riparian owners to fill in between them, and to connect the ends of the dikes by a continuous levee, thus giving a permanent river-bank, as demanded.

6. They point out the necessity for, and recommend, careful measurement of the slopes and volumes of the river at the highest and lowest stages, and careful surveys of the bed of the stream at all places where the general navigation requires an increase of depth at low water, between Saint Louis and the mouth of the Ohio.

For all of which the following estimates are submitted:

For erection of dike at harbor of Alton 6 feet above low water	$40,000 00
For protection of two miles of bank at Sawyer's Bend	142,211 62
For extension and raising of dikes in northern harbor of Saint Louis	197,323 90
For survey of the Mississippi River from Saint Louis to the mouth of the Ohio River	30,000 00
Total	409,535 52

The act of June 10, 1872, making appropriations for rivers and harbors, contains an appropriation of $25,000 for the improvement of the Mississippi River between the mouth of the Illinois River and the mouth of the Missouri, and also an appropriation of $100,000 for the improvement of the Mississippi River between the mouth of the Missouri and the mouth of the Maremec. These appropriations were based upon the report of the board of engineers above referred to, and the work provided for was immediately commenced.

(See Appendix I 10.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Of the examinations and surveys embraced in the second section of act of July 11, 1870, Lieutenant-Colonel Raynolds has, during the past year, submitted reports upon the improvements of the following rivers, which were duly transmitted to Congress at the time they were received at this office, viz:

1. *Ouachita River between Trinity, Louisiana, and Camden, Arkansas.*—(See Appendix I 11.)

2. *White River, from Buffalo Shoals to the mouth of James Fork, Missouri.*—(See Appendix I 12.)

3. *Black River, Missouri, to Poplar Bluff.*—(See Appendix I 13.)

4. *Bayou Bartholomew, from its mouth to the Arkansas State line.*—(See Appendix I 14.)

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5. *At Fourche La Faive, Arkansas.*—(See Appendix I 15.)

6. *At Cuivre River, Missouri, from its mouth to Moscow Mills.*—(See Appendix I 16.)

The following examinations and surveys provided for in the second section of the act of June 10, 1872, have been placed in charge of Lieutenant-Colonel Raynolds, and are in progress:

1. *Survey of the Mississippi River, between the mouth of the Missouri and the mouth of the Ohio.*

2. *Of Saint Francis River, from Greenville down, Missouri.*

3. *Of Gasconade River, Missouri.*

4. *Survey for the removal of wrecks and other obstructions placed in Yazoo River during the war, Mississippi.*

IMPROVEMENT OF THE OHIO RIVER.

Officer in charge, Major William E. Merrill, Corps of Engineers.

The contracts outstanding at the commencement of the last fiscal year were all completed during the year, except that for the dredging at Merriman's Bar, which was closed in July of this year. The contracts completed during the fiscal year were those for the dam at Chartier's Creek, the dam and dike at the Upper Twin Island, the dam at Marietta Island, the dike at Medoc, and the contracts for removing obstructions from the Ohio above and below the falls. Besides these a dike was partly constructed at Glass-house bar, and a large number of bowlders were removed from Horsetail and Lowery's.

Careful detailed surveys and maps were made, during the past year, of the bars at Horsetail, White's, and the Trap, Beaver and Raccoon Shoals, Line Island, Upper Twin Island, Charleston, Augusta, Snag Bar, Medoc, Rising Sun, Gunpowder, Warsaw, Craig's, and Grassy Flats, all of which are above Louisville; and at Evansville and Cumberland dam, below Louisville. Further surveys are now in progress.

The officer in charge recommends the construction of a light-draught snag-boat specially adapted to the Ohio River. He also again urges the necessity of a system of beacon-lights and buoys for the western rivers.

The appropriation of $200,000 made by the act of June 10, 1872, will be applied to the construction of the Glass-house dike, Chartier's Creek dam, Wheeling dam, Buffington dam and dike, Evansville dike, Cumberland dam, and to the removal of the wreck of the Black Hawk and of Bacon Rock, and also to the usual snagging and dredging operations. This distribution will give to the river above the falls $84,000, and to the river below the falls $93,000, leaving $23,000 for the usual snagging and dredging operations. One of the snag-boats, designed for use on the western rivers, has been temporarily transferred to this river, the funds applicable to other rivers not being sufficient to keep the snag-boat in service on them.

Amount on hand July 1, 1870	$76,059 89
Allotted for surveys	800 00
Received from sales of property	1,375 00
Amount appropriated by act of June 10, 1872	200,000 00
Amount expended during fiscal year ending June 30, 1872	77,659 70
Amount available July 1, 1872	200,575 19
Amount required for fiscal year, 1874	350,000 00

The act of June 10, 1872, contained an appropriation of $25,000 for the improvement of the Monongahela River between Morgantown and New Geneva, &c. This work will be commenced at Collin's Ripple, the point selected as the site for the first lock and dam.

(See Appendix K.)

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EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Harbor of Evansville, Indiana, (called for by resolution of the Senate of February 23, 1872.)—This survey was made to determine upon some method of improving the harbor of this city, which was in danger of destruction by the growth of a sand-bar above it. The report on this survey has been submitted to Congress and printed.

(See Appendix K 1.)

Cumberland dam, (called for by resolution of the House of Representatives of February 20, 1872.)—This survey was made in order to ascertain the propriety of completing the unfinished dam at the head of Cumberland Island, which was originally commenced with the intention of improving the entrance to the Cumberland River. The report has been submitted to Congress and printed.

(See Appendix K 2.)

Survey at head-waters of the Monongahela River.—This survey (required to be made by act of March 3, 1871,) has been completed, and the report thereon submitted to Congress and printed.

(See Appendix K 3.)

Survey of the Licking River as a harbor of refuge.—This survey (required to be made by act of March 3, 1871,) has also been completed, and the report on it laid before Congress and printed.

(See Appendix K 4.)

WATER-GAUGES ON THE MISSISSIPPI AND ITS TRIBUTARIES.

Officer in charge, Major William E. Merrill, Corps of Engineers.

These gauges have all been established, and the system is in good working order.

For Major Merrill's report, giving in detail the method of constructing these gauges, and their locations, see Appendix K 5.

IMPROVEMENT OF THE NAVIGATION AT THE FALLS OF THE OHIO RIVER AND ENLARGEMENT OF THE LOUISVILLE AND PORTLAND CANAL —IMPROVEMENT OF THE CUMBERLAND AND WABASH RIVERS.

Officer in charge, Major G. Weitzel, Corps of Engineers.

1. *Improvement at the Falls of the Ohio.*—Since the last annual report the dam across the river at the head of the canal has been about one-half completed; the apron-dam has been raised one foot, and 2,600 cubic yards of the rock ledge inside of the apron-dam have been blasted, and about 1,200 cubic yards of same placed in the dam across the river.

The enlargement of the entrance to the canal was completed, including new side walls. The widening of the whole main prism of the canal; the excavation of the basin joining the new branch with the old canal; the excavation of the new branch and the locks, lock-gates, and machinery, were all completed.

The new side walls were carried up to within about 5 feet of their ultimate height on parts 1, 4, and 5. On part 2 a small portion of these side walls was built and all the stone delivered for the remainder of the wall and also for the wall on part 3.

The high-water passage through the bridge was about two-thirds completed.

The excavation of the rock ledge at the outlet of the new locks was almost entirely completed. About 100 feet of the guide-wall below the new locks were built, and all the stone for the remainder of this wall delivered.

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The dam at the head of Sand Island was carried from the Indiana shore well into the island.

When the water was let into the canal, in November last, the miter sills of the new locks gave way. All the facts in the case were duly communicated to this office by the officer in charge, and a board of engineer officers was convened to report upon it. (See Appendixes L 3 and L 4.)

During the past season these sills have been rebuilt, and the remaining portions of the new side walls and the grading of the canal-banks placed under contract.

The appropriation of $300,000 made by the act of June 10, 1872, will be expended in completing these portions of the work.

The river and harbor bill, approved June 10, 1872, directed the Secretary of War to report to Congress, at its next session. or sooner if practicable, the condition of the canal at the Falls of the Ohio River, and the provisions necessary to relieve the canal from incumbrance, with a view to such legislation as will render the same free to commerce at its earliest practicable period. The report upon this subject, of Major Weitzel, and from this office, will be submitted to you at an early day.

Amount available July 1, 1871	$450,000 00
Amount appropriated by act of June 10, 1872	300,000 00
Amount received during the fiscal year ending June 30, 1872	420,000 00
Expenditures for same period	519,152 88
Remaining July 1, 1872	346,033 66
Amount required for the fiscal year ending June 30, 1874, and which can be profitably expended, and which will complete the work	200,000 00

(See Appendixes L 3 and L 4.)

2. *Improvement of Cumberland River below Nashville, Tennessee.*—Since my last annual report the river has been improved to Flax Patch, (inclusive,) and about 300 cubic yards of rock excavation done at Harpeth Island. The means still available from the appropriation made by the act of March 3, 1871, together with the $20,000 appropriated by the act of June 10, 1872, will probably carry the improvement to Reed's Reef, (inclusive.)

Amount estimated as the cost of the work, (see special report, survey of the Cumberland River, of January 20, 1871	$248,821 00
Appropriated by acts of March 3, 1871, and June 10, 1872	50,000 00
Amount still required to complete the work	198,821 00
Amount available July 1, 1871	30,000 00
Amount appropriated by act of June 10, 1871	20,000 00
Amount expended during fiscal year ending June 30, 1872	15,901 57
Amount available July 1, 1872, (which will all be expended during this fiscal year)	34,098 43
Amount required for fiscal year ending June 30, 1874, and which can be profitably expended	198,821 00

(See Appendix L 5.)

3. *Improvement of Wabash River, Indiana.*—The work of the present season will include dredging and snagging, commencing at the mouth of the river; improving the navigation at Coffee Island Chute, and some part of the work contemplated for the improvement of the navigation at Grand Chain.

The whole amount of the appropriation will be expended during the present fiscal year, if the stage of the river proves favorable.

Amount estimated as the cost of this work, (see special report, survey of Wabash River, of January 4, 1872)	$310,452 62
Amount appropriated by act of June 10, 1872	50,000 00
Amount still required	260,452 62

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No money was received and none expended during the fiscal year.

Amount available July 1, 1872	$50,000 00
Amount required for the fiscal year ending June 30, 1874	125,000 00

(See Appendix L 6.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Under the provisions of the act of March 3, 1871, Major Weitzel was charged with the completion of the surveys of the Upper Cumberland River and the Wabash River.

Reports upon the progress of the survey of the latter river were submitted to Congress in January, and of the former in February last.

(See Appendixes L 7 and L 8.)

IMPROVEMENT AND SURVEY OF THE TENNESSEE RIVER.

Officer in charge, Major Walter McFarland, Corps of Engineers, who had under his immediate orders Captain L. C. Overman and Lieutenants J. F. Gregory and B. D. Greene, Corps of Engineers.

The failure of the contractor, J. H. Dennis, to complete his contracts which had been running since October, 1868, and October, 1870, and which had been three times extended, and his refusal to accede to the conditions which were deemed necessary for the protection of the public interests in the further extension of his contract, for which he had applied, caused their annulment in April last, and the work on the lower river was re-advertised. But one bid was received, which was rejected, and the work is now going on by hired labor.

Owing to these circumstances but little work was done during the year, and that at Colbert Shoals. Nothing was done at Tumbling Shoals and Ross Tow-head, although the work had been laid out for the contractor.

The survey of the Muscle Shoals has been completed, and an estimate made of the cost of a steamboat-canal around the shoals from Brown's Ferry to Florence.

An examination of the Tennessee, from Knoxville to Chattanooga, has also been made, as well as estimates of the cost of its improvement so as to allow the passage of steamer of 3 feet draught.

A contract was made for improving the river above Chattanooga, and some work done at White's Creek. The contractor having failed, work is now being vigorously prosecuted by hired labor.

Required for the continuation of the improvement of the Tennessee below Chattanooga, including Muscle Shoals	$530,000 00
For the improvement of the Tennessee River above Chattanooga	120,000 00

(See Appendixes M 1 and M 2.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

The following, directed to be made by act of March 3, 1871, and a resolution of the Senate of March 3, 1871, have been completed, and the reports are herewith submitted:

1. *Tennessee River, from Brown's Ferry to Florence.*—(See Appendix M 3.)

2. *Examination and survey of Coosa and Etowah Rivers.*—(See Appendixes M 4, M 9, and M 10.)

3. *Examination of the Oostenaula River.*—(See Appendix M 5.)

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4. *Survey for a line of water-communication between the Mississippi River and the Atlantic Ocean, by way of the Ohio, Tennessee, Coosa, Etowah, Ocmulgee, and Altamaha Rivers, and canals from the Tennessee to the Coosa, and from the Etowah to the Ocmulgee.*—(See Appendixes M 6, M 7, and M 8.)

Major McFarland is charged with the survey of Tombigbee River between Fulton and Columbus, Mississippi, provided for in the second section of the act of June 10, 1872.

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER.—IMPROVEMENT OF BAYOU TECHE, LOUISIANA, AND OF GALVESTON HARBOR, TEXAS, AND REMOVAL OF THE RED RIVER RAFT.

Officer in charge, Captain C. W. Howell, Corps of Engineers, who has under his immediate orders Lieutenants H. M. Adams and E. A. Woodruff, Corps of Engineers.

1. *Improvement of the mouth of the Mississippi River.*—Work was suspended in July, 1871, leaving a wide, deep channel across the bar at Southwest Pass, and was not resumed until the middle of November following. During the time of suspension, which was a period of continued low water in the river, the channel deteriorated, but not so much as to inconvenience commerce. The suspension afforded opportunity for making repairs to dredging-machinery.

Work was recommenced on the 15th of November, 1871, and continued, as required, during the remainder of the fiscal year closing June 30, 1872. It was attended with highly satisfactory results.

Toward the close of the fiscal year a new dredge-boat, for which contract was made in the latter part of the preceding year, was completed.

During the summer and fall of the present year, work has been suspended, but will be resumed when necessary for the maintenance of a sufficient channel across the bar. Upon the active resumption of the fall trade of New Orleans, the full power of the two boats will be applied to determine what depth and width of channel can be maintained by working them throughout the year to their full capacity.

On June 30, 1872, there was available for the payment of outstanding indebtedness, and for continuing work during the present year, $175,275.74.

Amount required for the fiscal year ending June 30, 1874, $125,000.

Attention is again invited to the recommendation contained in my last annual report, for the enactment of laws to restrain individuals and corporations from willfully or carelessly injuring the channel provided by this work. The experience of the past year more clearly shows the necessity for the enactment of the laws suggested.

(See Appendix N 1.)

2. *Improvement of the inner bar at the entrance to Galveston Harbor, Texas.*—Preparations for prosecuting this work were completed by the construction of a dredge-boat and scows and the purchase of a tug-boat.

There was no occasion for using these on the bar, the capacity of the channel across the latter remaining, during the year, as great as that of the best channel across the outer bar.

During the present year this apparatus will be transferred to other work, and the appropriation available for the improvement of Galveston Harbor will be expended in extending and strengthening the jettee at Fort Point and in making a survey for the preparation of a plan for permanent works of improvement.

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June 30, 1872, there was available for the work, $30,162.47.

The estimate for the fiscal year ending June 30, 1874, will be dependent on the results of the survey this year.

(See Appendix N 1.)

3. *Improvement of Bayou Teche, Louisiana.*—This work, continued from the year preceding, was completed during the year, without exhausting the appropriation available, and has fully provided for the wants of the commercial interests concerned.

(See Appendixes N 1 and N 2.)

4. *Ship-canal to connect the Mississippi River with the Gulf of Mexico.*—In compliance with a resolution of the House of Representatives of March 14, 1871, requesting "an examination and survey, with plans and estimate of cost, to be made by an officer of the Corps of Engineers, for a ship-canal to connect the Mississippi River with the Gulf of Mexico, or the navigable waters thereof, of suitable dimensions for military, naval, and commercial purposes," the sum of $10,000 was allotted for the purpose from the appropriation of March 3, 1871, and the duty assigned to Captain Howell.

The survey has been made, and it is expected that the report will be received in time to submit to you in the early part of the next session of Congress.

The river and harbor improvement act, approved June 10, 1872, made appropriations "for the improvement of the Tangipahoa River, Louisiana;" "for improvement of Calcasieu Pass, Louisiana;" "for improvement of Tone's Bayou, Louisiana;" "for improvement of inner bar in Galveston Harbor, Texas;" "for improvement of Cypress Bayou, near Jefferson, Texas;" "for removing raft in Red River, Louisiana;" "for removing wreck of gun-boat Oregon in the Chefuncte River, Louisiana."

The work at Tangipahoa River consists in clearing the stream from all timber obstructions to navigation from its mouth to Wells's Ferry. The work is under contract.

Calcasieu Pass.—The work of improvement consists in the removal, by dredging, of about 30,000 cubic yards of the material forming the bar. It will be executed by the United States dredge-boat transferred for the purpose from Galveston Harbor.

Tone's Bayou.—The project for improvement at this point is to close gradually the bayou at its head, so as eventually to throw the whole discharge of the river (Red) through the old channel. The work is under contract.

Improvement of Cypress Bayou, Texas.—The work at this point will be done by a dredge-boat loaned for the purpose by the city of Jefferson, Texas, and will consist in clearing and deepening the bayou from Jefferson to the Caddo Lakes.

Removal of Red River raft.—The necessary boats, machinery, and appliances for this work have been, in part, purchased. The remainder are in course of construction. The work will be done by hiring the necessary labor therefor.

Removal of wreck of gun-boat Oregon in Chefuncte River, Louisiana.—Proposals were invited for this work, and bids received.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Captain Howell was charged with, and has completed, the following surveys directed to be made by the act of July 11, 1870:

1. *At Cypress Bayou, Texas.*—(See Appendix N 3.)

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2. *Examination and survey of Red River from the mouth to a point above the raft.*—(See Appendix N 3.)

Captain Howell is also charged with the following examinations and surveys provided for in the act of June 10, 1872:

1. *From the mouth of Nuches River, on Sabine Lake, to the mouth of the Angelica River, and thence to Pattonia, Texas.*
2. *Blo Buck Point Pass, Texas.*
3. *Ship-canal between the waters of Galveston Bay and Sabine Lake, Texas.*
4. *Harbor of Galveston, Texas.*
5. *Sabine River, from its mouth to Belzora, Texas.*
6. *Trinity River, from its mouth to Magnolia, Texas.*

IMPROVEMENT OF THE HARBOR OF MOBILE.—SURVEYS AND EXAMINATIONS OF RIVERS AND HARBORS IN ALABAMA AND WEST FLORIDA.

Officer in charge, Colonel J. H. Simpson, Corps of Engineers, who has under his immediate orders Captain A. N. Damrell, Corps of Engineers.

1. *Improvement of Mobile Harbor and Bay.*—Under the appropriation of $50,000 by the act of July 11, 1870, and the appropriation of $50,000 under the act of March 3, 1871, the contractors on the 11th June had opened the channel over Choctaw Bar to a depth of 13 feet at mean low water, and width of 200 feet, the only exception being directly in the gap of the upper obstructions, where there were some piles and an old wreck, to be removed by the State harbor-board, which they have since been engaged in effecting. When this is done and the remaining 8,000 cubic yards, which could not be reached with the dredge on account of the obstructions referred to, are removed, there will be a clear channel over Choctaw Bar of the width and depth mentioned above.

On the 11th of June the work of dredging Dog River Bar to the width of 200 feet and depth of 13 feet at mean low water was commenced by the contractors.

As the plans for improving the harbor and bay of Mobile, adopted by the board of harbor commissioners organized under authority of the State of Alabama, differed in some particulars materially from those adopted by the Engineer Department, a board of engineer officers was constituted for the purpose of examining the whole subject and preparing a plan for the improvement of the harbor and its channels. The report of the board has been approved and submitted to Congress, and printed. The project of improvement prepared by it did not require any modification of the plans previously followed by the Engineer Department, and the State board has conformed to them and co-operated with the officer in charge in carrying them out.

It is believed, with the appropriation of June 10, 1872, of $75,000, the balance on hand of previous appropriation, and the means at the disposal of the State board, that a clear cut can be made through Dog River Bar of 60 feet wide and 13 feet deep at mean low water, thus enabling vessels of this draught to ascend to the wharves of the city at high tide. Already the Choctaw Bar channel has been so greatly ameliorated as to render unnecessary the detour to the city by Spanish River, thus saving twelve miles in distance.

Amount available July 1, 1871	$79,285 24
Amount appropriated by act of June 10, 1872	75,000 00
Amount expended during the fiscal year ending June 30, 1872	58,705 39
Amount available July 1, 1872	95,579 85
Amount required for fiscal year ending June 30, 1874	200,000 00

(See Appendixes O and O 1.)

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EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Of the examinations and surveys embraced in the acts of July 11, 1870, and of March 3, 1871, Colonel Simpson has, during the past year, submitted reports upon the improvements of the following localities, which were duly transmitted to Congress at the time they were received at this office:

1. *Mouth of the Appalachicola River, Florida.*—The survey was commenced in January, and completed, as far as allotment from appropriation would allow, in the early part of July, 1871.

Colonel Simpson recommends dredging the channel through the bar at the mouth of Appalachicola River, from 11 feet curve inside to 11 feet curve outside of bar, to a width of 100 feet and 11 feet deep; the width to be afterwards increased, if found expedient, to 150 or 200 feet.

The estimate for the whole work is $100,000, and the officer in charge recommends an appropriation of $50,000 of this amount for the next fiscal year.

(See Appendix O 2.)

2. *Chattahoochee River, below Columbus, Georgia.*—The survey was brought to a close at Eufaula, sixty-three and one-half miles below Columbus, for want of further funds, and the reports thereon transmitted to Congress. Detailed estimates of work necessary at different points between Columbus and Eufaula, and also between this last place and mouth of Appalachicola River, are given in this report. The obstructions are grouped into three classes: the first class, actually stopping navigation at low water; the second, having about a foot more in depth of water, needing improvement very much; the third class, though not of much importance, needing improvement, to prevent changes for the worse in future.

The estimate for the removal of the first class of obstructions, is	$464,000
For the second class, is	327,000
For the third class, is	85,185
To complete survey of the Chattahoochee River will require	5,000
Survey of Flint River, very much recommended	8,000
Survey of Appalachicola River, much recommended	10,000

(See Appendix O 3.)

3. *Examination and survey of the mouth of Saint Mark's River, from Spanish Hole to Saint Mark's, Florida.*—The estimated cost of improving the channel from the Gulf of Mexico to Saint Mark's to a depth of 9 feet and width of 200 feet, is given by Colonel Simpson, at $40,866.10. The officer in charge is of opinion that the present channel is more than sufficient to accommodate the very limited business done at Saint Mark's, and it is in contemplation by the Jacksonville, Pensacola, and Mobile Railroad to extend their road to deep water at Spanish Hole, below which there is a good channel to the Gulf for vessels drawing less than 9 feet.

(See Appendix O 4.)

4. *Examination of the Choctawhatchee River.*—The examination shows that there are available at all times, between the mouth of the river and Geneva, at least 8 feet of water, 3 feet more than can be carried through the Narrows at the east end of Santa Rosa Sound; and that the obstructions consist principally of snags, sawyers, overhanging trees, and two wrecks of steamboats. The improvements proposed are the removal of the obstructions mentioned, and the straightening of the channel in places.

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Colonel Simpson submits three estimates. The first, amounting to $98,716.80, contemplates a thorough improvement of the river; but the present commerce, in his opinion, will not justify so large an expenditure. The second, amounting to $52,291.20, contemplates not so exhaustive an improvement, but one which would be sufficient to meet all present and prospective requirements for many years to come. The third estimate, amounting to $34,332, is for the removal of obstructions which make the navigation of the river both difficult and dangerous, even for the amount of trade done on it at the present time. This amount is about 10 per cent. of the value of the merchandise carried on the river during the past year; and it is believed this extent of improvement will be sufficient for at least five years to come.

(See Appendix O 5.)

5. *Examination and survey at Tampa Bay, Florida.*—The officer in charge submits three estimates for this improvement:

1. For a straight channel, with a width at base of 200 feet and slope of 2.5 feet horizontal to 1 foot vertical, and a uniform depth of 12 feet mean low tide; estimated cost $502,121.90.

2. For deepening the present sailing-channel, which he prefers, 200 feet wide at base, 12 feet deep, and slope 2.5 to 1; estimated cost $549,621.80.

3. For deepening the present sailing-channel; width at base 100 feet, slope 2.5 to 1, depth 12 feet; estimated cost $287,475.65.

Colonel Simpson, in view of the magnitude of any one of these projects, and the liability of the channel to fill up, recommends, as preferable, (for private enterprise,) the construction of a railroad from the city of Tampa to Passage Point. This point is only about nine miles from Tampa, affording a good site for an entrepot; and what gives it especial value, vessels drawing 18 feet of water can approach it within one-quarter mile. The railroad could be made and stocked for less than $20,000 per mile, or $180,000 for the whole distance, and as the city of Tampa, at no distant day, will be connected by rail with the Florida Railroad to the north of it, he has no doubt that the extension of the road to Passage Point will naturally follow as a consequence.

For these reasons, and the present limited demands of commerce in this section, he does not recommend any expenditure for the improvement of the harbor of Tampa.

(See Appendix O 6.)

EXAMINATIONS AND SURVEYS.

Under the act of June 10, 1872, Colonel Simpson is charged with—

1. *Survey of Appalachicola River from Chattahoochee, Florida, to Appalachicola.*

2. *Survey of Chattahoochee River from Columbus, Georgia, to Chattahoochee.*

3. *Survey of Flint River from Albany, Georgia, to Chattahoochee, Florida.*

4. *Survey of the harbor of Cedar Keys, Florida.*

IMPROVEMENT OF HARBORS AND RIVERS ON THE ATLANTIC COAST SOUTH OF CAPE FEAR.

Officer in charge, Major Q. A. Gillmore, Corps of Engineers, who has Captain Ludlow, Corps of Engineers, under his immediate orders.

1. *Improvement of the Ship-channel in Charleston Harbor.*—A contract

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was made for the removal of the following wrecks: the Palmetto State, in the mouth of Town Creek; the Charleston and the Chicora, two wrecks near each other in Cooper River below Drum Island; the Beatrice and her companion, two wrecks near the inner mouth of Beach Channel upon the north side of Drunken Dick Shoal. These have been entirely removed, and the contract closed.

Over the positions occupied by the Palmetto State, the Charleston, and the Chicora, there is now a depth of 12 feet at mean low water. The Beatrice and her companion were taken out to a low-water depth of 15 feet, in fulfillment of the contract, but sand has since accumulated upon the sites, and changes are constantly going on, giving a variable depth of 9½ to 11 feet at mean low water. The positions require dredging.

A contract was also made for the removal, to a depth of 25 feet mean low water, of the wreck of the Monitor Patapsco, near Fort Sumter. At the close of the fiscal year a depth of 19 feet had been obtained over the wreck. At the last accounts the contract is nearly completed.

It is proposed to expend the appropriation of June 10, 1872, with the unexpended balance on hand, substantially as follows: In removing the following wrecks:

1. A wreck near Fort Sumter to a depth of 27 feet at mean low water.

2. The Monitor Weehawken, in main channel abreast of Morris Island, to a depth of 20 feet.

3. Gun-boat Housatonic, outside main bar, in the track of northern-bound vessels, to a depth of 20 feet; and in dredging Beach Channel to a depth of 15 feet and a width of 275 feet, and dredging in the positions of the wreck of the Beatrice and her companion, and removing 125 linear feet from the end of Bowman jetty and the remains of a contiguous wreck.

No further appropriation is required.

(See Appendix P 1.)

2. *Improvement of Savannah Harbor and River, Georgia.*—It is contemplated to expend the appropriation of June 10, 1872, substantially as follows: In removing a crib sunk in the channel below Fort Jackson, and nine cribs and a wreck in the north channel opposite the upper end of Elba Island; in dredging on the sites of the cribs and wrecks removed; and in dredging a channel 125 feet wide at the following points and low-water depths on the shoal below Fig Island to a depth of 12½ feet; on the shoal near the head of Elba Island to a depth of 12½ feet; on the flats abreast of Elba Island to a depth of 12½ feet; opposite the lower end of Elba Island to a depth of 12½ feet; and on the flats northeast of Fort Pulaski to a depth of 12 feet.

For the continuance of this work of widening and deepening the channel, and for the removal of the remaining sunken cribs and of three wrecks, there will be required, for the fiscal year ending June 30, 1874, $100,000.

(See Appendixes P 2 and P 3.)

3. *Improvement of the bar at the mouth of Saint John's River, Florida.*—Efforts to deepen the channel over the bar at the mouth of the Saint John's River by contract having failed, the officer in charge chartered a steamer and fitted it with a 9-inch centrifugal drainage-pump, two 6-inch suction-pipes, and two rows of timberbins on deck for holding the sand pumped up from the bar.

The pump-engine was driven by steam from the steamer's boiler, and the sand pumped up was discharged into deep water outside the bar by flooding the bins with the pump running at full speed in clear water. This method of dredging was successful, and was followed for a period

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of eight months—from the 1st of November, 1871, to the 30th of June, 1872—with the exception of a short interval while the boat was detached for other work. Forty thousand seven hundred and sixty-four cubic yards of sand were removed and discharged into deep water outside the bar, at an average cost for current expenses of $50\frac{9}{10}$ cents per cubic yard.

The new channel opened is 10 feet deep, over 150 feet wide, and about 800 yards long, at mean low water. Its direction is due east and west.

As the mean rise and fall of the tide on the Saint John's Bar is $5\frac{4}{10}$ feet, the mean high-water depth in the new channel is over 15 feet, and vessels drawing 13.5 to 14 feet can easily cross without striking, except in very heavy weather. This is a greater draught than can be carried over the shoals in the vicinity of Dame's Point, between the mouth of the river and Jacksonville, upon which there are only 12.7 feet depth at high tide.

It is recommended that a channel 9.6 feet deep at low water on the bar, and 11.3 feet deep at low water over the shoals, be maintained for the accommodation of vessels of a maximum draught of 14 feet.

It is not expected that the new bar-channel will be permanent, and expenditures will have to be made annually to maintain it.

The engineer in charge recommends the appropriation of $20,000 for the improvement of this river, to be applied to dredging upon the bar at the mouth of the river, and upon the shoals in the vicinity of Dame's Point and San Carlos Creek.

Amount available July 1, 1871	$29,665 93
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	29,803 51
Amount available July 1, 1872	9,862 42
Amount required for fiscal year ending June 30, 1874	20,000 00

(See Appendixes P 4 and P 5.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Gillmore is charged with the resurvey of Savannah Harbor, directed to be made by section two of act of June 10, 1872.

IMPROVEMENT OF THE SUSQUEHANNA, PATAPSCO, WICOMICO, NORTHEAST, POTOMAC, (ABOVE LONG BRIDGE,) RAPPAHANNOCK, JAMES, APPOMATTOX, ROANOKE, AND CAPE FEAR RIVERS, AND AQUIA AND ACCOTINK CREEKS, VIRGINIA; HARBORS OF QUEENSTOWN, CAMBRIDGE, AND WORTON CREEK, MARYLAND.

Officer in charge, Major W. P. Craighill, Corps of Engineers, who has under his immediate orders Captain C. B. Phillips, Corps of Engineers.

1. *Improvement of Susquehanna River, near Havre de Grace.*—The material of the old movable deflector was applied in the construction of a fixed wooden dike, to concentrate the flow of the water below the railroad-bridge, as had been proposed and partially accomplished by the former temporary work. Operations were suspended at the end of October, 1871, the dike being nearly 4,000 feet long. As was anticipated, this wooden structure was somewhat injured by the ice of winter and the freshets of spring, but its advantageous influence has been demonstrated. A permanent dike should be built.

Amount expended in fiscal year ending June 30, 1872	$7,469 06
Amount available for fiscal year ending June 30, 1873	6 30
Amount required for fiscal year ending June 30, 1874	50,000 00

(See Appendix Q 1.)

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2. *Improvement of Northeast River, Maryland.*—Under a call from Congress for information, an examination of this river was made in April, and a report submitted under date of April 8, 1872.

An appropriation of $10,000 was made June 10, 1872, which it is proposed to expend in making a channel from a point about 4,500 feet from the town of Northeast to that town, about 60 feet wide at bottom and 5 feet deep at mean low water, and, if possible, to extend it, with less width to Alexander's Mill, about 1,000 feet further.

No expenditure in last year.

Amount available for fiscal year ending June 30, 1873, $10,000.

No further appropriation required.

(See appendix Q 2.)

3. *Improvement of the entrance to the Harbor of Baltimore, in Patapsco River and Chesapeake Bay.*—Dredging has been continued in the Brewerton Channel and in the lower channel, under contracts to be completed in 1872, the extent of which was 25,000 cubic yards in the Brewerton Channel, and 60,000 yards in the lower channel. The recent appropriation of June 10, 1872, of $100,000, will be at once put under contract, and should result in the removal of not less than 300,000 yards from the lower channel. A board of improvement has been organized by the authorities of the city, and $200,000 have been placed at their disposal for immediate expenditure. The design is to make the width of the lower channel 400 feet, and of the upper channel 250 feet, both 24 feet deep at low water. The money now in hand and in course of expenditure on the part of the city will provide for the removal of not less than 650,000 yards. The officer in charge calls attention to the hurtful encroachments made by wharves, &c., upon the tidal reservoir pertaining to this important harbor.

Amount available July 1, 1871	$92,010 58
Amount appropriated June 10, 1872	100,000 00
Amount expended during fiscal year ending June 30, 1872	57,093 69
Amount available for fiscal year ending June 30, 1873	134,916 89
Amount required for fiscal year ending June 30, 1874	200,000 00

(See Appendix Q 3.)

4. *Improvement of Wicomico River, near Salisbury, Maryland.*—A survey was made of this locality early in 1871, and an estimate of the cost of improvement submitted. The improvement needed was found to be the opening of a channel, by dredging, about 75 feet in width and 7 feet in depth at mean low water, from the termination of the existing 7-foot channel to the bridge. At present prices the cost will be about $20,000, the citizens providing the dikes at their own expense, in accordance with their offer. An appropriation of $5,000 was made June 10, 1872, which it is proposed to expend in 1872 in making a channel about 25 feet in width and 7 feet in depth at low water.

Amount expended during the fiscal year ending June 30, 1872	$———
Amount available for the fiscal year ending June 30, 1873	5,000 00
Amount required to complete, according to estimate, which may be expended in fiscal year ending June 30, 1874	15,000 00

(See Appendix Q 4.)

5. *Improvement of Worton Harbor, Maryland.*—Under a call from Congress for information, an examination of this place was made in April, and a report submitted under date of April 18, 1872. An appropriation of $12,000 was made June 10, 1872, which it is proposed to expend in 1872 in making a channel from the head of Worton Creek to the confluence of Tims and Worton Creeks, a distance of about 2,000 feet, about 100 feet wide at bottom and 7 feet deep at mean low water.

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No expenditure in last year.
Amount available for fiscal year ending June 30, 1873, $12,000.
No further appropriation required.
(See Appendix Q 5.)

6. *Improvement of Queenstown Harbor, Maryland.*—At the close of the year ending June 30, 1871, the contractor was engaged in dredging a channel in the creek to a depth of 8 feet at mean low water. The appropriation of $5,000 was exhausted and the dredging brought to a close July 25, 1871. One cut of the required depth, and of a width of 25 feet, was completed, and a second cut nearly so.

The appropriation of $6,000, made June 10, 1872, will be expended in widening the channel and giving greater capacity to the harbor. This improvement will probably be completed in 1872.

Amount available July 1, 1871	$2,364 80
Amount appropriated by act of June 10, 1872	6,000 00
Amount expended in fiscal year ending June 30, 1872	2,440 80
Amount available for fiscal year ending June 30, 1873	5,924 00

(See Appendix Q 6.)

7. *Improvement of the Harbor of Cambridge, Maryland.*—At the close of the year ending June 30, 1871, the contractor was engaged in dredging. The appropriation was exhausted about the end of August, 1871, when the work of dredging came to a close. A channel, 100 feet in width and 9 feet in depth at low water, was made from the Choptank River to the mouth of the creek leading into the inner basin. A channel of the same depth, and 50 feet in width, was carried into the inner basin, and some excavation of the same depth was done in the inner basin, to facilitate the use of the railroad-wharf. The remainder of the appropriation was applied to the improvement of the exterior harbor and the inner basin. The appropriation of $10,000, made June 10, 1872, will be expended in continuing the improvement of the outer harbor and the inner basin, the entrance to the former, and the channel between them. The improvement will probably be completed in 1872.

Amount available July 1, 1871	$7,525 43
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended in fiscal year ending June 30, 1872	7,602 43
Amount available for fiscal year ending June 30, 1873	9,923 00

(See Appendix Q 7.)

8. *Improvement of Potomac River, above Long Bridge, D. C.*—The dredging of the Virginia or Georgetown Channel was completed in December, 1871, to a width of 200 feet and a depth of 15 feet at low water, the material being deposited behind Analostan Island.

Under authority of an act of Congress a commission, designated by that body, has under consideration the subject of the further improvement of the river. The following estimate is presented, subject to modification when the opinion of that commission is made known:

Amount available July 1, 1871	$23,431 46
Amount expended in fiscal year ending June 30, 1872	22,880 34
Amount available for fiscal year ending June 30, 1873	550 62
Amount asked for fiscal year ending June 30, 1874	160,000 00

(See Appendix Q 8.)

9. *Improvement of Accotink Creek, Virginia.*—A survey was made of this locality in June and July, 1871, and a report rendered under date of January 22, 1872. An estimate was submitted, amounting to $19,000, for giving a channel up to the village of Accotink, 40 feet wide at bottom and 5 feet deep at mean low water.

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An appropriation of $5,000 was made June 10, 1872, which it is proposed to expend in 1872 making a channel to the town of Accotink, about 2½ feet deep at mean low water, and as wide as the funds will permit.

Amount expended during fiscal year ending June 30, 1872	$———
Amount available for fiscal year ending June 30, 1873	5,000 00
Amount required to complete, according to estimate, which may be expended in fiscal year ending June 30, 1874	14,000 00

(See Appendix Q 9.)

10. *Improvement of Aquia Creek, Virginia.*—A survey was made of this locality in June and July, 1871, and a report rendered January 22, 1872. An estimate was submitted, amounting to $18,000, for giving a channel from the 6-foot water near the mouth of the creek to the "Narrows" above, 40 feet in width at bottom and 6 feet deep at mean low water.

An appropriation of $1,500 was made June 10, 1872, which it is proposed to expend in 1872 in making a channel from the draw in the railroad-bridge up toward the "Narrows" as far as practicable, 20 feet wide at bottom and 4 feet deep at mean low water.

Amount expended during fiscal year ending June 30, 1872	$———
Amount available for fiscal year ending June 30, 1873	1,500 00
Amount required to complete, according to estimate, which may be expended in fiscal year ending June 30, 1874	16,500 00

(See Appendix Q 10.)

11. *Improvement of the Rappahannock River below Fredericksburg.*—Dredging was continued until suspended by ice in December, 1871, giving channels through Spottswood and Fredericksburg Bars of 70 feet in width and 8 feet in depth at low water. Several wrecks, injuriously affecting the regimen of the river, have been removed. It is proposed to expend the appropriation of $15,000 of June 10, 1872, in extending the channels already dredged, and in building dikes, with the double object of contracting the water-way and increasing the flow through the dredged channel, and providing a receptacle behind which to deposit the material removed from the channel.

Amount available July 1, 1871	$14,489 13
Amount appropriated June 10, 1872	15,000 00
Amount expended in fiscal year ending June 30, 1872	11,263 03
Amount available for fiscal year ending June 30, 1873	18,226 10
Amount required for fiscal year ending June 30, 1874	65,000 00

(See Appendix Q 11.)

12. *Improvement of James River, Virginia.*—Mr. Maillefert has removed wrecks and other obstructions in the river at Drury's Bluff, in such a successful manner as to restore the fine channel originally existing at that point. The Dutch Gap cut-off was opened to the use of navigators early in January, 1872, to a width of about 135 feet at the water-line. A land-slide of moderate extent occurred on the southern bank of the cut-off, in March, 1872, injuring somewhat the appearance of the new channel, but not seriously impeding its use. The *debris* will soon be removed. The contractors having failed to open the required channel through the rock at Rockett's Reef, the work has been taken in hand by the supervising engineer, and is progressing satisfactorily toward completion. The operations of the authorities of the city have been chiefly confined to dredging, and to the construction of dikes behind which to deposit the dredged material. These dikes serve also to rectify advantageously the banks and water-way, and thus improve the regimen of the stream.

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Amount available July 1, 1871	$67,831 38
Amount appropriated June 10, 1872	50,000 00
Amount expended in fiscal year ending June 30, 1872	42,417 64
Amount available for fiscal year ending June 30, 1873	75,413 74
Amount required for fiscal year ending June 30, 1874	100,000 00

(See Appendix Q 12.)

13. *Improvement of the Appomattox River below Petersburg.*—Dredging has been in progress in the south channel under contract. Its extent was 150,000 cubic yards, and it has been satisfactorily completed. Its object was to give a channel about 60 feet wide at bottom and about 10 feet deep at low water. Another contract for dredging 50,000 yards from the Puddle-dock cut has been nearly completed. This cut is intended to be about of the same dimensions as the cut in the south channel, of which it will be the prolongation when both are opened. It is proposed to expend the appropriation of $40,000, of June 10, 1872, in completing the cut through the south channel and the Puddle-dock marsh, and in turning the river through the new channel.

It is expected that these results will be attained before June 30, 1873. This channel will be of the minimum width, which should be increased. The river also needs improvement at the bars between the Puddle-dock marsh and the city of Petersburg.

Amount available July 1, 1871	$49,293 70
Amount appropriated June 10, 1872	40,000 00
Amount expended in fiscal year ending June 30, 1872	41,586 70
Amount available for fiscal year ending June 30, 1873	47,707 00
Amount required for fiscal year ending June 30, 1874	75,000 00

(See Appendix Q 13.)

14. *Improvement of Roanoke River, below Weldon.*—Contracts are in force for removing wrecks from the lower portion of the river, as well as some dangerous rocks near Weldon. Delay has taken place, owing to freshets in the river and the prostration of the contractor by severe malarial illness. These operations will be completed in 1872. A boat has been fitted up at moderate expense for machinery, and provided with a crew, for the removal of snags, overhanging trees, and similar obstructions which have proved dangerous to navigation. The work of this boat has been satisfactory, both as regards progress and useful results.

Amount available July 1, 1871	$19,779 25
Amount appropriated June 10, 1872	10,000 00
Amount expended in fiscal year ending June 30, 1872	8,782 18
Amount available for fiscal year ending June 30, 1873	20,997 07
Amount required for fiscal year ending June 30, 1874	10,000 00

(See Appendix Q 14.)

15. *Improving Cape Fear River, below Wilmington, North Carolina.*—The work for closing the opening between Smith's and Zeke's Islands has been carried forward successfully, having been lengthened nearly 1,200 feet during the year, and being nearly half a mile long June 30, 1872. The sand accumulates around it with gratifying rapidity. In addition, attention has continued to be given to the maintenance of existing sand-hills and beaches, and to the formation of new ones, by the use of cheap catch-sand fences, which have succeeded well. Shrubbery and other vegetation suited to the locality have also been planted and cultivated to advantage, with the same object.

A board of engineers was convened at Wilmington early in 1872, to consider the results of the work already done, and to give opinions as to the proper steps to be taken in the future. A final report has not been made, the board having concluded that no change, at least for the

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present, was needed in the project of operations in execution, and that it was expedient to defer a judgment until the completion of a survey then in progress of the mouths of the river. It is expected that the data will soon be provided which will enable the board to submit a report.

Amount available July 1, 1871	$72,485 82
Amount appropriated June 10, 1872	100,000 00
Amount expended in fiscal year ending June 30, 1872	75,436 49
Amount available for fiscal year ending June 30, 1873	97,049 33
Amount required for fiscal year ending June 30, 1874	150,000 00

(See Appendix Q. 15.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Craighill was charged with, and has during the fiscal year submitted to this office reports upon, the following, viz:

1. *Worton Creek, Kent County, Maryland.*—Under a call for information, an examination of this river was made in April last. For the report submitted to this office, see Appendix Q 16.

2. *Northeast River, Maryland.*—Under a call for information, an examination of this river was made in April last, and a report submitted to this office.

(See Appendix Q 17.)

3. *Ship-canal, Chesapeake and Delaware Bay.*—In reply to the resolution of the House of Representatives, of March 11, 1872, requesting information upon the subject of the construction of a ship-canal from the waters of the Chesapeake to the waters of Delaware Bay, the subject was investigated as far as available means permitted, and a report, with estimates, was submitted March, 1872, and printed in Ex. Doc. No. 234, House of Representatives, Forty-second Congress, second session.

(See Appendix Q 18.)

4. *Aquia Creek, Accotink, Neabsco, Quantico, and Choppawamasic Bays.*—Surveys of these waters were directed in the appropriation bill of March 3, 1871. A report with maps was submitted January 22, 1872, and printed in Ex. Doc. No. 35, Senate, Forty-second Congress, second session.

These are tributaries of the lower Potomac, presenting similar characteristics of expansion near the mouth to a wide shallow bay with soft bottom, while at the upper portion of the course the channel becomes more contracted, and winds its way through flats and marshes. Plans of improvement are submitted, in the report already referred to, for each of these places except Quantico, where nothing seems required at present. The estimates are, in round numbers, as follows:

1. Aquia Creek, to obtain 6 feet water at low water	$18,000
2. Accotink, to obtain 5 feet water at low water	19,000
3. Neabsco, to obtain 6 feet water at low water	13,500
4. Choppawamasic, to obtain 10 feet water at low water	7,000
Or 12 feet at low water	10,000

The increase of depth of water in these channels would no doubt give impetus to the enterprise which is beginning to manifest itself in this region, and the benefit would not be confined to the localities themselves, but would be directly participated in by Washington and Alexandria, as well as by other towns on the Potomac and Chesapeake.

(See Appendix Q 19.)

5. *Norfolk Harbor and Elizabeth River.*—This survey was directed in the appropriation bill of March 3, 1871. A report, with maps, was

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submitted January 31, 1872, and printed in Ex. Doc. No. 43, Senate, Forty-second Congress, second session.

Elizabeth River, through its southern branch, is connected with the waters of Albemarle Sound by the Dismal Swamp Canal, (in which the United States have a pecuniary interest as the owners of eight hundred shares of its stock,) and by the Albemarle and Chesapeake Canal, eight miles further up the stream. These two canals are the principal outlets of the commerce of Northern and Eastern North Carolina. The officer in charge estimates that, to obtain the depth of 7 feet at low water as far up as the lock of the Albemarle and Chesapeake Canal, would require an expenditure of about $25,000. He also reports that the sum of $30,000 could be advantageously expended in the next fiscal year in improving the approaches from the sea to the harbor of Norfolk.

(See Appendix Q 20.)

6. *Nansemond River, Virginia.*—This survey was directed in the appropriation bill, dated March 3, 1871. A report, with maps, was submitted January 6, 1872, and printed in Ex. Doc. No. 23, Senate, Forty-second Congress, second session.

The officer in charge estimates, for the improvement of this river below Suffolk, by dredging a channel over Suffolk Bar and Western Branch Bar, of 100 feet in width and 8 feet in depth at low water, constructing dikes at the entrance of Western Branch Bar and the removal of obstructions to navigation, such as wrecks, piles, fallen trees, snags, &c., amounting, in all, to $30,000, which sum could be judiciously expended in a single year.

An increase of the width of the proposed channel from 100 to 200 feet would add $20,000 to the cost of the dredging.

(See Appendix Q 21.)

7. *Roanoke River, below Weldon, North Carolina.*—This survey was directed in the appropriation bill approved July 11, 1870. The lateness and unhealthiness of the season, when the appropriation became available, caused a postponement of field-work until late in the fall. A preliminary report was made by the officer in charge, dated January 17, 1871, which is printed in Ex. Doc. No. 60, part 2, House of Representatives, Forty-first Congress, third session. A final report, with maps, was made December 5, 1871, which has been printed in Ex. Doc. No. 23, Senate, Forty-second Congress, second session.

The results of this survey were the following: From the mouth of the river to Indian Highlands Landing and Bar, a distance of about sixty-five miles, there is at all seasons a sufficient depth for vessels drawing about 10 feet, which is more than is required for the trade through Albemarle Sound and the canal. A few troublesome wrecks were found in this portion of the river, which are now nearly all removed by contract, the funds therefor being derived from the appropriation of March 3, 1871. Some snags and fallen trees needed taking out, but funds were already available from the same appropriation. Above Indian Highlands Landing to Weldon, about fifty-five miles, the river is so variable in depth as not to afford a continuous low-water navigation of more than 2 or 3 feet. This portion of the stream is therefore considered the only part calling at this time for any large expenditure for its improvement. The cost of removing the obstructions and dredging the shoals and bars of this portion of the river, so as to insure a 5-foot navigation at low stage, in a channel-way of not less than 60 feet in width, is estimated at $120,000; but it is believed that the prevalence of high freshets, and their effects on the bed of the river, would endanger the permanence of such improvements, and that the circumstances of the case seem to require a

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resort to the use of training-dikes (of piles wattled with saplings) in order to contract the low-water channel of the stream. By this expedient it is highly probable that the low-water depth of 5 feet may be obtained and maintained without resort to dredging. The following estimates for this method of improvement are submitted:

1. Removing snags, sunken logs, &c	$25,000 00
2. Removing rocks, &c., near Weldon	10,000 00
3. Training-dikes, 156,000 linear feet, at $1.50	234,000 00
	269,000 00

Deducting amounts available, a sum to be appropriated is left of $249,000.

It has been suggested that the interests involved justify and demand the maintenance of a depth, below Weldon, of not less than 8 feet at all seasons. To do so would probably require an additional expenditure of $250,000; but it is by no means certain that such a depth could be obtained and made permanent.

(See Appendix Q 22.)

8. *Neuse River, below Goldsborough, North Carolina.*—This survey was directed in the appropriation bill of March 3, 1871, and was completed in June of the same year. A report, with maps, was submitted to Congress, and printed in Ex. Doc. No. 23, Senate, Forty-second Congress, second session.

The Neuse River, between Goldsborough and New Berne, a distance of about ninety-seven and a half miles, flows through a low, heavily-timbered country. Its channel is, in parts, tortuous and obstructed by snags and sunken logs, and has a width varying from 80 to 250 feet, with a minimum depth of 4½ feet. Below New Berne it may be considered an estuary, and furnishes sufficient depth of water for the commerce of the place.

The improvements made by the State of North Carolina previous to the war, consisting of the construction of wing-dams and the removal of snags, have so far ameliorated the condition of the river as far up as Contentnea Creek, thirty-one and a half miles above New Berne, that, excepting artificial obstructions placed during the war, the section of the river now particularly requiring improvement may be considered as between Contentnea Creek and Goldsborough, a distance of about sixty-six miles; and the officer in charge recommends that, should an appropriation be made for the improvement of this river, it be limited for the present to the amount needed for the removal of snags, logs, fallen trees, overhanging trees, and artificial obstructions, which he estimates would cost $51,000.

(See Appendix Q 23.)

9. *Cape Fear and Deep Rivers, as far up as La Grange, North Carolina.*—This survey was directed in the appropriation bill of March 3, 1871, and was begun at La Grange in June, 1871. A report, with maps, dated June 1, 1872, was submitted by the officer in charge, embracing that portion of the river from La Grange, on the Deep River, to Federal Point, on the Cape Fear, below Wilmington. The remaining portion of the lower Cape Fear, including the bars and channels from the sea, has been lately surveyed by a party detailed from the office of the United States Coast Survey. Considerable sums of money have been spent by the United States in the improvement of the Cape Fear River, below Wilmington. That subject is now being considered by a board of engineers, from which a report may soon be expected.

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The improvement of the Dape Fear River, above Wilmington, and of its tributaries, would doubtless develop highly important sources of wealth and revenue, of interest, in a national point of view, as set forth by the engineer in his report, and by others referred to by him.

This improvement would, however, obviously be very expensive. The estimates must be considered as only approximate. It could not be otherwise, with the limited means at disposal for the examination of so long a stretch of country. They indicate the certainty that a permanent improvement of that portion of the river would be very costly, and should only be entered upon after minute and thorough surveys in detail.

(See Appendix Q 24.)

10. *The Dismal Swamp Canal.*—Under a call from the Senate for information, an examination of this canal was made in March and April, 1872, and a report submitted by the officer in charge April 30, 1872.

(See Appendix Q 25.)

11. Major Craighill has also been charged with surveys or examinations of the following localities, directed to be made in the act of June 10, 1872. It is expected that reports upon these will be received in time for action by Congress at its next session:

1. *The Mouth of Nomoni Creek and Occoquan River, Virginia.*
2. *Chester River, at Kent Island Narrows, Maryland.*
3. *Washington Harbor, North Carolina.*
4. *Edington, Harbor, North Carolina.*
5. *Mouth of Mackay's Creek, North Carolina.*
6. *To complete the Survey of the James River and Kanawha Canal.*
7. *Great Kanawha River, from the Great Falls to the mouth, West Virginia.*
8. *The New River, from the mouth of Greenbrier, in West Virginia, to the lead mines in Wythe County, Virginia.*

CONSTRUCTION OF THE DELAWARE BREAKWATER AND OF THE PIER AT LEWES, DELAWARE.—HARBOR-IMPROVEMENTS ON DELAWARE RIVER AND BAY.—IMPROVEMENT OF THE SCHUYLKILL, AND OF SOUTH AND SHREWSBURY RIVERS, NEW JERSEY.

Officer in charge, Lieutenant-Colonel J. D. Kurtz, Corps of Engineers, having under his immediate orders Captain M. R. Brown, Corps of Engineers.

1. *Delaware Breakwater.*—The board of engineer officers constituted October, 1871, to examine into the condition of the harbor of refuge formed by the Delaware breakwater, and to report a plan for such additions to or modifications of the harbor-works as may be requisite to accommodate the existing and growing wants of commerce, has completed the duties assigned to it.

Of the various propositions for modifying the harbor the three following came under the consideration of the board:

1. To prolong the ice-breaker to the eastward till it laps the breakwater sufficiently to exclude the sea. Estimated cost, $1,944,950.

2. To construct a detached work in advance of the gap of sufficient length to cover it at both ends. Estimated cost, $2,278,000.

3. To fill the gap between the breakwater and ice-breaker with stone, uniting the two structures, and making the whole a continuous barrier to the sea. Estimated cost, $1,314,200.

This last proposition was adopted by the board, with one dissenting

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voice, that of the officer in charge, Colonel Kurtz, and the first two rejected.

A thorough survey of the harbor and vicinity has been completed the past year, with current observations. An investigation to ascertain the nature of the bottom at various points was made in connection with the construction of the iron landing-pier now in progress. Final surveys of the ice-breaker and breakwater have been completed, and drawings made, showing in detail the present condition of these works.

During the present working season it is proposed to commence a careful set of meteorological investigations of wave-intensity, experimentally.

Amount available July 1, 1871	$3,665 33
Amount expended during fiscal year ending June 30, 1872	2,647 03
Amount available July 1, 1872	1,018 26

(See Appendixes R 1 and R 2.)

2. *Construction of pier near Lewes, Delaware.*—Last year the position of the pier was fixed, in general terms, in conformity with the recommendation of a board of engineer officers, whose report was approved. The exact location was left subject to the decision of the local engineer in charge.

After a careful survey, consisting of soundings, artesian borings into the bottom of the harbor, a mechanical analysis of the several kinds of soil, &c., and trial-tests of the power of the different strata in various places to sustain vertical pressure, made with loaded disks sunken to different depths, a position was chosen for the pier affording a depth at the pier-head which will render it available for all vessels entering the harbor, and which guarantees comparative calmness of water alongside the work. At the same time the location is so chosen as to make the cost of the structure as moderate as a serviceable iron pier could be built for anywhere in the harbor.

Various kinds of screws have been tested, and one devised for use in the work. It is modeled for withdrawal as well as insertion, and has proved entirely successful.

Experiments to determine the best method of inserting piles led to the adoption of mule-power, assisted by a newly-discovered application of the water-jet to the upper surfaces of the flanges of the screws while in rotation. Contracts for the material required were entered into and are partly filled.

A reservation of 11½ acres of ground has been obtained from the State of Delaware, and six temporary buildings erected thereon. A stone abutment has been built, and suitable machinery procured.

The construction of the pier proper was begun on the 15th of April. Two hundred and thirty-one feet were completed at the end of the fiscal year.

The work will be steadily advanced during the present working season, and can be completed in 1873, if the necessary means are appropriated by Congress.

Amount available July 1, 1871	$221,007 50
Amount expended during fiscal year ending June 30, 1872	51,748 55
Amount available July 1, 1872	169,258 95
Amount required for fiscal year ending June 30, 1874, to complete the work	163,000 00

(See Appendixes R 3 and R 4.)

3. *Harbor at Marcus Hook, Pennsylvania.*—Nothing is needed at this harbor beyond placing more securely the ladders which give access to

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the mooring-posts on the tops of the piers. This will be done this season.

Amount available July 1, 1871	$15,914 69
Amount expended during fiscal year ending June 30, 1872	4,782 80
Amount available July 1, 1872	11,131 89

(See Appendix R 5.)

4. *Wilmington Harbor, Delaware.*—The appropriation of $15,000 made for the improvement of this harbor has been applied to increasing the depth of water and widening the channel at the mouth; out through the bar to the Delaware River channel; along up towards the mouth of Brandywine Creek, and between Third and Market streets. About 28 cubic yards of fast rock have been removed from mid-channel, a short distance above Third street bridge.

It is proposed to expend the appropriation of June 10, 1872, in dredging the channel below mouth of Brandywine Creek, between Third and Market streets, and above Market street; also, to remove a rock from mid-channel above Third street bridge.

There is a cluster of rocks in the bed of the river, just below Third street bridge. These should be removed. It is recommended that an appropriation of $6,000 be made for this work.

Amount available July 1, 1871	$12,260 56
Amount expended during fiscal year ending June 30, 1872	12,260 56
Amount appropriated by act approved June 10, 1872	10,000 00
Amount available July 1, 1872	10,000 00
Amount required for year ending June 30, 1874	6,000 00

(See Appendix R 6.)

5. *Repairing ice-harbor piers at New Castle, Delaware.*—The appropriation of $27,000 will be applied to removing from the harbor part of an old pier that was never finished; to completing the repairs of an existing pier; and to work on one of the new piers of the Delaware ice-harbor at this position.

Amount appropriated by act of June 10, 1872, and available July 1, 1872	$27,000 00
Appropriation asked for year ending June 30, 1874	50,000 00

And it is suggested that so much of the balance remaining unexpended of the appropriation for "improving harbor at Marcus Hook, Pennsylvania," as may not be needed there, be appropriated to the ice-harbor piers at New Castle Harbor, Delaware.

(See Appendix R 7.)

6. *Clearing and improving the channel of the Schuylkill River, Pennsylvania.*—The appropriation applicable for the year ending June 30, 1872, ($10,000,) was expended in clearing several shoal spots left in the cut at the mouth of the river, giving a channel 150 feet wide and 18 feet deep at low water; in continuing the cuts at Gibson's Point; and in removing a shoal extending into the channel at the petroleum-wharves, near Point Breeze.

The appropriation of $40,000, of June 10, 1872, now available, will be expended in widening and deepening the cut at the mouth of the river; connecting the 18-feet channels above Penrose Ferry bridge; completing the cuts through the shoal at Gibson's Point; removal of rock extending into the channel near Locust street; and in connecting the 18-feet channels at several points where the depth is deficient, between Chestnut street bridge and Gibson's Point.

The coming year, it is proposed to increase the depth of the river at its mouth to 20 feet at low water, and to carry this depth up to Gibson's Point, the seat of heavy shipments of petroleum in vessels drawing

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over 22 feet water. An appropriation is asked for the next fiscal year for these purposes of $40,000.

Amount available July 1, 1871	$9,903 25
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during fiscal year ending June 30, 1872	9,903 25
Amount available for year ending June 30, 1873	40,000 00
Amount required for fiscal year ending June 30, 1874	40,000 00

(See Appendix R 8.)

7. *Improvement of South River, New Jersey.*—Unavoidable delay in awarding the contract for this improvement, and obstacles caused by owners of the land bordering on the canal, prevented the completion of this work last year. The cuts through the canal will be completed this season.

A considerable part of the excavation being through sand, that is in some degree quick, it has flowed in from the sides so as to distribute the effect of the dredging over a wide space, with corresponding reduction in the depth effected. To correct this, some further dredging is desirable, for which a small appropriation is asked.

Amount available July 1, 1871	$15,000 00
Amount expended during fiscal year ending June 30, 1872	10,113 32
Amount available July 1, 1872	4,886 68
Amount required for fiscal year ending June 30, 1874	5,000 00

(See Appendix R 9.)

8. *Improvement of the north and south branches of Shrewsbury River, New Jersey.*—The unavoidable delay in commencing the execution of this work prevented its completion during 1871. Good channels have been excavated through the shoal places at the entrance to South Shrewsbury River; around Rocky Point, in the North Shrewsbury River; at Jumping Point, in the South Shrewsbury; and two cuts have been made through the bulk-head at the mouth of the river at Sandy Hook Bay. This last locality is being further improved and a channel excavated.

The dredging operations on this improvement have been successful, and afford a fair promise of channels that will maintain themselves through the shoal places. To remedy such embarrassment as may take place in them, to give a trumpet-shape to the openings of the cuts, and for some additional work at Jumping Point, (the route for freight to Long Branch,) a small appropriation is required.

Amount available July 1, 1871	$13,802 50
Amount expended during fiscal year ending June 30, 1872	9,170 54
Amount available July 1, 1872	4,631 96
Appropriation required for year ending June 30, 1874	5,000 00

See Appendix R 10.)

9. *Improvement of Delaware River between Trenton and Bordentown, New Jersey.*—The appropriation of $10,000 for this work, in the act of June 10, 1872, will be applied during the present season.

In order to effect any serviceable improvement, the sum of $30,000 should be appropriated for the next fiscal year.

Amount appropriated by act of June 10, 1872, and available July 1, 1872	$10,000 00
Appropriation required for year ending June 30, 1874	30,000 00

See Appendix R 11.)

10. *Survey of Horseshoe Shoals, Delaware River, Pennsylvania.*—In the act of March 3, 1871, provision is made for the survey of Horseshoe Shoals, in the Delaware River, below Philadelphia, the object being, no

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doubt, to have an examination made of the difficulties attending the winter navigation of this part of the river, and to obtain practical suggestions and plans for such relief as can be provided.

No great difficulties are encountered from ice on the ebb-tide. There is sufficient width to the river to enable it to pass without serious jamming, and if ascending vessels are pressed they can take refuge in the ice-harbors at Marcus Hook, New Castle, &c. When the tide turns to flood, however, the embarrassments begin, and increase as the river is ascended. The final closing of the channel takes place at the latter part of the flood, and above the Horseshoe buoy, toward the gorge at Gloucester and Greenwich Points.

Lieutenant-Colonel Kurtz, the officer in charge of this examination, classes the remedies for this into three heads, viz: first, breaking up the ice and removing it by active machinery; second, meliorative treatment of the locality by works of construction and by improvement of the water-way; and, third, avoidance of the obstructed part of the river by the construction of lateral unincumbered channels. He gives preference to the second of these remedies, and gives plans and estimates of the cost of open ice-barriers, to be placed at intervals, from the navy-yard reach of the river to that of League Island.

The cost of the first class of remedies, *i. e.*, the original cost and the maintenance of ice-boats, of suitable number and power, is set down as equivalent to the permanent sinking of $1,000,000; of the second class, open ice-barriers, estimates are submitted in detail amounting to $1,062,778; of the third class, an open cut 150 feet wide at bottom, and 25 feet deep at low tide, from the back-channel at Broad street bridge to the old powder-wharf at Gloucester Point, is estimated at $1,300,000.

(See Appendixes R 12 and R 13.)

11. *Survey of the Broadkiln River, Delaware.*—On the 11th of March, 1872, the House of Representatives requested the Secretary of War "to cause to be made an examination and survey of Broadkiln River, in the State of Delaware, with a view to ascertaining the practicability of dredging and improving the same so as to afford greater protection and facilities to commerce, and that he report upon the feasibility of making such improvement, and the cost thereof, to the House of Representatives."

The nature of the work, involving improvements at several localities, rendered necessary the preparation of several charts, and it was found impracticable to prepare these in season for transmission to the House of Representatives before adjournment. The report, estimates, and charts are now complete. In order to accomplish the work desired by the commercial interests involved, an appropriation of $80,447 is needed.

The estimates are based on the unanimous wish of all concerned to have a channel in the Broadkiln River, which shall allow the passage of vessels drawing 6 feet at low water.

(See Appendix R 14.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Lieutenant-Colonel Kurtz is charged with the following, directed to be made by act of June 10, 1872:

1. *At Cohansey Creek, New Jersey.*

2. *The bay or sound from Delaware line through Worcester County to Chincoteague Inlet, Virginia, with a view to an inlet at or near a place called the Hommacks.*

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3. *The Delaware River, between Trenton and Easton.*

The first of these surveys is complete; the others are in progress. All the maps and reports are expected to be complete in season for the information of Congress, at the approaching session.

IMPROVEMENT OF HUDSON RIVER.—REMOVAL OF OBSTRUCTIONS IN EAST RIVER, INCLUDING HELL-GATE.—IMPROVEMENT OF PASSAIC RIVER, AND OF THE HARBORS OF PORT CHESTER AND RONDOUT, NEW YORK.

Officer in charge, Lieutenant-Colonel John Newton, Corps of Engineers, who has under his immediate orders Captain W. H. Heuer and Lieutenant J. H. Willard, Corps of Engineers.

1. *Improvement of Hudson River.*—During the fiscal year the removal of Overslaugh Rock by blasting was partially completed. The least depth at mean low water is $11\frac{7}{10}$ feet.

A cut 1,400 long and 60 feet wide, to a depth of 8 feet at mean low water, was made through Fish-house Shoal, and some repairs were made to Base Island and Patroon's Island crib-dikes, and the filling of same with rubble-stone was commenced.

A cut 1,900 feet long and 25 feet wide, to a depth of 12 feet at mean low water, was made in the Overslaugh Channel. A cut 500 feet long and 30 feet wide, to a depth of 13 feet at mean low water, was made through a point of the Coeyman's Bar, which projected into the main channel, and a cut 900 feet long and 25 feet wide, to a depth of 8 feet at mean low water, was made in the small channel leading to Coeyman's.

Dike No. 1, at Coeyman's, 2,056 feet, commenced and finished.

Dike No. 2, at Coeyman's, $816\frac{9}{12}$ feet, commenced and finished.

Dike No. 3, at Coeyman's, 1,380 feet, commenced and finished.

Some repairs also were made to dike No. 1, at Coeyman's.

Amount available July 1, 1871	$65,464 64
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during fiscal year ending June 30, 1872	50,056 48
Amount available July 1, 1872	55,408 16
Amount required for fiscal year ending June 30, 1874	143,000 00

(See Appendix S 1.)

2. *Removing obstructions in East River, including Hell-Gate.*—The following statement exhibits the length to which the several tunnels and galleries at Hallett's Point have been driven:

	Feet.		Feet.
Tunnel No. 1	185	Tunnel No. 5c	34
Tunnel No. 1a	82	Tunnel No. 6	233.8
Tunnel No. 2	172	Tunnel No. 7	240
Tunnel No. 3	196	Tunnel No. 8	214
Tunnel No. 4	202	Tunnel No. 9	179
Tunnel No. 4a	79	Tunnel No. 9a	89
Tunnel No. 5	190	Tunnel No. 10	152
Tunnel No. 5a	79	Tunnel No. 10a	18
Tunnel No. 5b	$23\frac{1}{2}$	Transverse galleries	$835\frac{3}{4}$

The number of feet of tunnels driven during the year was 1,653, and of transverse galleries, $653\frac{3}{4}$. The quantity of rock removed was 8,293 cubic yards.

The "Burleigh" and "Diamond" drills have been used for drilling, the former having drilled $20{,}160\frac{1}{10}$ feet, and the latter 7,071 feet. The drills have been run by compressed air, five compressers having been put up for that purpose.

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Tunnels Nos. 2, 3, 4, 5, 6, 7, and 8, are advanced to their full length or nearly so.

Steam-drilling Scow.—Diamond Reef.—On this reef 76 holes have been drilled and blasted, and 44 surface-blasts have been made. Four thousand seven hundred and ninety-six pounds of nitro-glycerine have been used. Some little work yet remains to be done to this reef before the required depth of water is obtained—24 feet at mean low water.

Coenties Reef.—This reef has been thoroughly broken up to the required depth, and is supposed to need but a few surface-blasts to complete the entire dislodgment of the broken rock. The number of holes drilled and blasted was 93, and surface-blasts 17, there having been 5,479 pounds of nitro-glycerine used. The broken rock on Diamond and Coenties Reefs has been removed by a grappling-machine; the total amount taken from both reefs being 6,119 tons.

"*Frying-Pan Rock.*"—During the latter part of the year the scow was removed to this reef, and 15 holes drilled and blasted, after which the scow was removed to "Pot Rock," and a few holes drilled, but the principal object is first to remove the broken stone with which the rock is covered.

Amount available July 1, 1872	$323,982 46
Amount received for use of steamer, and loss of row boat	256 00
Amount appropriated by act of June 10, 1872	225,000 00
Amount expended during fiscal year ending June 30, 1872	316,838 93
Amount available July 1, 1872	232,399 53
Amount required for fiscal year ending June 30, 1874	600,000 00

(See Appendix S 2.)

3. *Improvement of Passaic River.*—The amount of $25,000, appropriated by act of June 10, 1872, besides detailed surveys of Belleville and Rutherford Park Bars, will be devoted to the improvement of Belleville Bar.

There is asked, for the improvement of other bars up to Passaic, an appropriation of $44,000, which will open the navigation of the upper reach of the river.

(See Appendixes S 3 and S 6.)

4. *Improvement of the Harbor of Port Chester, New York.*—A survey in detail has been finished of "Salt" and "Sunken" Rocks.

The amount of $12,000, appropriated by act of June 10, 1872, is to be devoted to removal of "Salt Rock."

Amount necessary for removal of "Sunken Rock," $59,000, which, to be efficiently applied, should be available in one sum.

(See Appendixes S 4 and S 7.)

5. *Improvement of Rondout Harbor, Hudson River, New York.*—The amount appropriated by the act of June 10, 1872, $10,000, will be applied to the construction of about 563 feet of the north dike.

The officer in charge recommends that the amount, $104,000, required for the north and south dikes, and for dredging a new channel, be appropriated in one sum for the fiscal year ending June 30, 1874.

(See Appendixes S 5 and S 8.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Lieutenant-Colonel Newton is charged with the following examinations or surveys directed to be made by the act of June 10 1872:

1. *At Keyport Harbor, New Jersey.*
2. *For a breakwater at Rouse's Point, New York.*
3. *Of channel between Staten Island and New Jersey.*
4. *Of harbor at Swanton, Vermont.*

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IMPROVEMENT OF RIVERS AND HARBORS IN THE STATES OF CONNECTICUT AND RHODE ISLAND, AND ON THE SOUTH SHORE OF LONG ISLAND SOUND.

Officer in charge, Major G. K. Warren, Corps of Engineers.

1. *Improvement of Pawtucket River, Rhode Island.*—Under the appropriation of March 3, 1871, a beginning was made to secure a channel 7 feet deep at mean low water. During the fiscal year, 21,122 cubic yards were removed from the channel-way. There is still a part of the channel, about 1,500 feet in length, over which there is a depth at mean low water of only 5½ feet, the rest being from 6 to 7 feet deep. The mean rise of tide is 5 feet, so that vessels drawing 10½ feet can pass out at ordinary high water. To complete a channel 75 feet wide and 7 feet deep at low water, will require the removal of 35,000 cubic yards, at a cost of $15,400.

This river will require something to be done annually to preserve its depth, as there is a large amount of silt brought into it by sewers and small streams.

Amount available by act of July 1, 1871	$8,092 20
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	8,092 20
Amount available July 1, 1872	10,000 00
Amount required for fiscal year ending June 30, 1874	10,000 00

(See Appendix T 1.)

2. *Improvement of Providence River, Rhode Island.*—No work was done on this river during the last fiscal year, there being no funds. Under the appropriation of $10,000 made by act of June 10, 1872, advertisement was made for dredging at the "Crook," and at the point opposite Sassafras Point, to increase the width of the channel at those places.

Amount required for fiscal year ending June 30, 1874, $10,000.

3. *Construction of Harbor at Block Island, Rhode Island.*—During the fiscal year the cribs inclosing the inner harbor were completed, the main breakwater was carried out to a point about 550 feet beyond the inner harbor, and was nearly completed up to mean sea-level. The amount of stone placed in the work during the year is about 7,500 tons; the whole amount in the work at the close of the fiscal year was about 13,500 tons.

It was found necessary, during the past year, to construct a jettee from a point on the shore west of the main work, to arrest the heavy waves that roll in from the eastward, and reach around the breakwater, abrading the shore, and causing a deposit in the angle between the shore and breakwater. The funds left of appropriation made March 3, 1871, will be used in dredging in the inner basin, and removing rocks from the space inclosed by the main breakwater. The appropriation of $50,000 made by act of June 10, 1872, will be chiefly expended in completing and extending the main breakwater, and lengthening out the jetty.

Amount available July 1, 1871	$82,686 50
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during fiscal year ending June 30, 1872	54,002 05
Amount available July 1, 1872	78,684 45
Amount required for fiscal year ending June 30, 1874	100,000 00

(See Appendix T 3.)

4. *Improvement of Pawcatuck River, Rhode Island and Connecticut.*—It is now designed to make a channel 50 feet wide and 5 feet deep at

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mean low water up to Westerly. The work is continuous, difficult dredging much of the distance above "The Rocks." The channel is opened only a part of the way. The following work was done in the last fiscal year: removal of 12,930 cubic yards of material, and 401¼ hours' work of dredge.

Amount available July 1, 1871	$9,840 85
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	9,651 15
Amount available July 1, 1872	10,189 70
Amount required for fiscal year ending June 30, 1874	10,000 00

(See Appendix T 4.)

5. *Improvement of Thames River, Connecticut.*—It is expected that the work under the appropriatian of $15,000, made by act of March 3, 1871, will be completed during the present season, and a channel 100 feet wide and 11 feet deep at mean low water, be made up to the "Rolling-Mill Wharf." It is thought that the appropriation of $10,000 made by act approved June 10, 1872, will open a channel of the same capacity up to the docks in Norwich, and remove a portion of the "Middle Ground." A contract has been made for doing the work. Investigations into past records show that the jettees or wing-dams, constructed some years ago, have not diminished the height of the tide sensibly at Norwich.

Amount available July 1, 1871	$15,333 73
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during the fiscal year ending June 30, 1872	7,225 45
Amount available July 1, 1872	18,108 28

(See Appendix T 5.)

6. *Improvement of Connecticut River below Hartford.*—During the fiscal year dredging was done at Hartford Bar, Pratt's Ferry Bar, Glastonbury Piers, and Bristol Point Bar, giving a channel 8 feet deep at lowest water.

The piling at Hartford Bar was completed. Under the appropriation of $40,000, made by act of June 10, 1872, it is designed to complete the survey of Saybrook Bar at the mouth of the river, to remove a wreck from this bar, and to deepen it, and do such dredging in the river as may be necessary. Some dredging must be done annually in the Connecticut River.

Amount available July 1, 1871	$52,829 28
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during the fiscal year ending June 30, 1872	52,583 15
Amount available July 1, 1872	40,246 13
Amount required for fiscal year ending June 30, 1874	40,000 00

(See Appendix T 6.)

7. *Improvement of Connecticut River above Hartford, Connecticut, and below Holyoke, Massachusetts.*—During the fiscal year wing-dams were built at Scantic River Bar, Strong's Island Bar, and Farmington Bar. The work at the last was interrupted by a rise in the river. The continued high water prevented a resumption of the work, or even examination to ascertain the condition and effect of what was done.

A careful survey was made of Enfield Rapids, and plans and estimates for a canal around them prepared, which accompany this report.

The nature of the improvements recommended for the Enfield Rapids is such that nothing essential can be done with the sum appropriated by act of June 10, 1872, $20,000. Its expenditure was limited to the Enfield Rapids and the river between them and Holyoke. A careful

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survey will be made of the river, when the water is low, from Enfield to Holyoke, to ascertain what is most needed.

Amount available July 1, 1871	$19,392 57
Amount appropriated by act of June 10, 1872	20,000 00
Amount expended during fiscal year ending June 30, 1872	1,541 43
Amount available July 1, 1872	37,851 14

No appropriation is asked for fiscal year ending June 30, 1874.

(See Appendix T 7.)

8. *Improvement of New Haven Harbor, Connecticut.*—During the year a survey of the harbor, including the rocks at the entrance and the mouths of Mill and Quinnipiac rivers was made. A channel 200 feet wide at mean low water was dredged from the 13-feet curve up to Long wharf, a distance of 3,125 feet. Thence up to the "canal-dock," a distance of 750 feet, it was made 300 feet wide; thence to the steamboat-wharf, a distance of 2,125 feet, it was made 100 feet wide; the depth throughout at mean low water was 13 feet.

There have been removed from Luddington Rock 227 cubic yards. It is proposed to complete the removal of the rock down to the depth of 17 feet mean low water.

Dredging is to be done on the bar near Fort Hale, under the appropriation of June 10, 1872, so as to give 15 feet depth at mean low water.

Amount available July 1, 1871		$44,753 87
Amount appropriated by act of June 10, 1872, for improvement of New Haven Harbor	$20,000	
Amount appropriated for removal of rock, New Haven Harbor	15,000	
		35,000 00
Amount expended during fiscal year ending June 30, 1872		35,726 63
Amount available July 1, 1872		44,027 24
Amount required for fiscal year ending June 30, 1874		25,000 00

(See Appendix T 8.)

9. *Improvement of Housatonic River, Connecticut.*—During the last fiscal year a wing-dam was built at the Sow and Pigs Rocks, connecting them with the left bank. At Drew's Bar a channel 80 feet wide, and 7 feet deep at mean low water, was dredged, and at Mill Bar one 42 feet wide, and of the same depth. With the funds available the current fiscal year, dredging will be done between Derby and Huntington, and at Two-mile Island Bar, Crofut's Bar, and at the bar at the mouth of the river, as may be needed. An embankment will be made to connect Drew's Rock with the right bank. A thorough survey has been made of the mouth of the river.

Amount available July 1, 1871	$14,676 70
Amount appropriated June 10, 1872	15,000 00
Amount expended during fiscal year ending June 30, 1872	13,751 81
Amount available July 1, 1872	15,924 89
Amount required for fiscal year ending June 30, 1874	20,000 00

(See Appendix T 9.)

10. *Improvement of Bridgeport Harbor, Connecticut.*—During the past fiscal year a thorough survey was made of the harbor. This showed the depth on the bars to be essentially the same as when surveyed by Lieutenant Blake, United States Navy, in 1837, and that all channels dredged in the intervening period had filled up. A jetty running out from Long Beach to arrest the westward motion of the sand was therefore begun at the high-water line, and is now built out 52 feet. Dredging was also done at the outer and inner bars, and at a shoal opposite Cook's Point, so as to give about 7½ feet over them at low

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water. When the jetty is extended, so as to have a length of about 2,500 feet, it is designed to dredge the channel to a depth of 12 feet at mean low water, as it is expected then that the increased current in the confined entrance will maintain the channel at that depth. The work will consist the present fiscal year in lengthening out the jetty and dredging at such places as may require it.

Amount available July 1, 1871	$17,954 10
Amount appropriated June 10, 1872	40,000 00
Amount expended during fiscal year ending June 30, 1872	17,952 87
Amount available July 1, 1872	40,001 23
Amount required for fiscal year ending June 30, 1874	60,000 00

(See Appendix T 10.]

11. *Improvement of Westport Harbor, Connecticut.*—No appropriation has been made for this work since the act approved March 3, 1871. The amount available was merely sufficient to make a good survey, which was much needed. The survey has been made, and a report and plan of improvement will be submitted.

Amount available July 1, 1871	$2,679 81
Amount expended during fiscal year ending June 30, 1872	2,035 15
Amount available July 1, 1872	644 66

(See Appendix T. 11.)

12. *Survey and Improvement of Norwalk Harbor, Connecticut.*—This survey was made during the fiscal year ending June 30, 1872, and the report is annexed. (See Appendix.) It was estimated that to dredge the channel so as to have 6 feet depth and 100 feet width at mean low water up to Norwalk, would cost $34,000. The act approved June 10, 1872, appropriated $10,000 for commencing the work, and a contract has already been made to excavate a channel 60 feet wide and 6 feet deep from the stone bridge down to Jennings's wharf. This will improve the worst part of the river, but it will not be fully available till the deepening is extended further down the river.

Amount available July 1, 1872	$10,000 00
Amount required for fiscal year ending June 30, 1874	20,000 00

(See Appendix T 12.)

13. *Survey and improvement of Huntington Harbor, Long Island, New York.*—The survey was made in the fiscal year ending June 30, 1872, and the report of it is annexed.

An estimate was submitted of the work to be done to make a channel 200 feet wide and 8 feet deep at mean low water at the entrance, and to carry the 8-feet channel up to the public wharves on the east side with a width of 150 feet. The amount required was placed at $22,780.

The act approved June 10, 1872, appropriated $22,500. This latter sum was available at the beginning of the fiscal year July 1, 1872, and no further appropriation is asked for.

Contract has been made for doing the work.

(See Appendix T 13.)

14. *Improvement of Port Jefferson Harbor, Long Island, New York.*—During the first part of the last fiscal year a very accurate survey was made to ascertain what changes had taken place since 1838, the time of the last United States coast survey. It was found that the entrance had moved westward at an annual average rate of 24 feet. The plan of improvement was based upon this result. It was to build a jetty on the east side to arrest the movement of bowlders and pebbles westward under the action of the waves, and to do no dredging until the jetty extended out beyond the bar.

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The jetty was begun last spring, and has been extended about 600 feet, with the money appropriated by the act approved March 3, 1871. The building of this jetty or breakwater will be continued with the funds appropriated by the act approved June 10, 1872, a contract for it having been made.

Amount available July 1, 1871	$15,000 00
Amount appropriated June 10, 1872	15,000 00
Amount expended in fiscal year ending June 30, 1872	4,231 72
Amount available July 1, 1872	25,768 28
Amount required in fiscal year ending June 30, 1874	20,000 00

(See Appendix T 14.)

15. *Improvement of Peconic River, Long Island, New York.*—During the fiscal year the appropriation of $5,000 was expended in dredging. With this a channel 25 feet wide and 4 feet deep at mean low water was extended up to River Head.

The estimate now made for the least improvement that will be useful is $28,000 additional. This sum will make a channel 75 feet wide and 6 feet deep, up to Merritt's Bay.

The appropriation of $10,000, made June 10, 1872, will be applied to carrying out the above plan, as far as it will go. A contract has been made for doing the work.

Amount available July 1, 1871	$5,000
Amount appropriated June 10, 1872	10,000
Amount expended in fiscal year ending June 30, 1872	5,000
Amount available July 1, 1872	10,000
Amount required in the fiscal year ending June 30, 1874	10 000

(See Appendix T 15.)

16. *Survey of Stonington Harbor, Connecticut.*—This survey was completed and a report and map submitted, dated December 18, 1871; the report was printed as part of Senate Ex. Doc. No. 23, second session of Forty-second Congress, and is also attached to this report.

The estimate was, for removing the present breakwater to Stonington Point, and continuing it out to 17½ feet of water, at mean low water	$350,000
For sea-wall at Wampasset Point	70,000
	420,000

No appropriation was made for this work.
(See Appendix T 16.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Warren has been charged with the following surveys, directed to be made by the act approved June 10, 1872:

1. Providence River, "on the east side, between Field's Point and Fox Point, Rhode Island."
2. Wickford Harbor, Rhode Island.
3. Newport Harbor, Rhode Island.
4. Niantic River, Connecticut.
5. Breakwater at Milford, Connecticut.

The surveys at Wickford and Newport have been made, and the others will be made during this season and reported in time to be submitted to Congress at the next session.

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SEA-WALLS AT GREAT BREWSTER, DEER, AND LOVELL'S ISLANDS, BOSTON HARBOR.

Officer in charge, Colonel H. W. Benham, Corps of Engineers.

1. *Great Brewster Island.*—The sea-walls are in excellent condition, fully protecting the bluffs of the island, and without causing any injury or abrasion to the shores at their extremities.

The wharf and nearly all the buildings have been removed during the last year, for reconstruction at the works for the protection of Long Island Head.

No appropriation is now required for this work.

2. *Deer Island.*—The three sea-walls are generally in good condition, giving essential protection to the bluffs of the island; for the reconstruction, however, of a portion of the wall of the north head, as was designed, had the funds on hand sufficed, and for some further protection by jettees to the long faces of these walls, the officer in charge recommends an appropriation of $18,000.

3. *Lovell's Island.*—The new sea-wall on the east of the main bluff, or hill, is in excellent condition in all parts, as are the shores at its extremities. The old wall at Ram-Head is also in good condition, except at its west extremity, where it has been injured by storms to some extent. And as the shore-line, next west, immediately adjacent, is wearing away rapidly, the officer in charge recommends, to provide as security against this, an early appropriation of $15,000.

(See Appendix U.)

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATES OF MAINE, NEW HAMPSHIRE, AND MASSACHUSETTS.

Officer in charge, Lieutenant-Colonel George Thom, Corps of Engineers, who has under his immediate orders Captain W. S. Stanton and Lieutenant J. B. Quinn, Corps of Engineers.

1. *Saint Croix River, above the "Ledge," Maine.*—For the improvement of this river it will be necessary to deepen its channel, by the removal of slabs, edgings, and saw-dust, which, for thirty years and more, have been accumulating in large quantities. The act of Congress, approved March 2, 1867, by which $15,000 was appropriated for this work, contained a proviso requiring the co-operation of the province of New Brunswick before operations should be commenced. This co-operation not having been obtained the appropriation has reverted to the Treasury. An appropriation of $50,000 on the part of the United States, with an equal amount on the part of the province of New Brunswick, will be required to accomplish this work, of which amount one-half could be profitably expended during the next fiscal year.

(See Appendix V 1.)

2. *Narraguagus River, Maine.*—The improvement contemplated for this river comprises the removal of a large quantity of ledges and bowlders from its channel, between its mouth at Millbridge and the bridge at Cherryfield, a distance of about seven miles. Of these there were broken up and removed during the fiscal year ending June 30, 1872, about 1,100 bowlders of various sizes, weighing in all about 1,200 tons, and a ledge at the "falls" about 1,000 tons. Previous to July 1, 1871, there were removed about 250 bowlders, weighing in all about 550 tons; the total quantity removed being about 2,750 tons.

Amount appropriated by act of March 3, 1871	$12,000 00
Amount appropriated by act of June 10, 1872	10,000 00

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Amount available July 1, 1871	$10,095 61
Amount expended during fiscal year ending June 30, 1872	8,335 25
Amount available July 1, 1872	11,760 36

No further appropriation is required.
(See Appendix V 2.)

3. *Sullivan River and Sullivan Falls, Maine.*—The only obstructions to the navigation of this river and falls, from the mouth up to Franklin, a distance of about nine and one-half miles, are Hatcher's Rock and Ledge in the falls, and the foundations of several bridge-piers in the river, about one mile above the falls. Under the appropriation of $10,000 made by act of March 3, 1871, about 300 cubic yards were blasted off the top of Hatcher's Rock, by which 4 feet more water were obtained over it, there being now 3½ feet over it at ordinary low water, and 11½ feet at high water. The contemplated work remaining to be done consists in the removal of Hatcher's Rock to a depth of 9 feet at mean low water, the removal of the point of ledge near it to a depth of 7 feet, the removal of two bridge-piers, and placing iron spindles on "Half-tide Rock" and "Low-water Rock," below the falls, the estimated cost of which is $25,000.

Amount of funds on hand July 1, 1871	$9,773 03
Amount expended during the fiscal year ending June 30, 1872	9,773 03
Amount appropriated by act of June 10, 1872	25,000 00

Which is sufficient for completing all the improvements contemplated.
(See Appendix V 3.)

4. *Union River, Maine.*—The improvement of this river consists in the removal of a large quantity of slabs, edgings, sawdust, and bowlders, between Ellsworth (the head of navigation) and Fullerton's Point, and of several sunken ledges and very large bowlders at its mouth. A contract was made for opening a channel of 150 feet wide through these obstructions at and below Ellsworth, for the sum of $12,000. On the 30th of June, 1871, this channel was opened to a width of about 100 feet, and about forty large and dangerous sunken bowlders had been removed from the channel of the river, at its mouth and above. Since then, the channel at and below Ellsworth has been opened for an additional width of 50 feet; a large quantity of slabs, edgings, and bowlders has been removed from the river in front of the wharves at Ellsworth, and more than 800 tons of sunken ledges and bowlders have been removed from the channel of the river, at its mouth and above.

The only work remaining to be done during the present fiscal year was the placing of an iron beacon on Fullerton's Point, for which the balance on hand the 1st of July, 1872, was deemed sufficient. The beacon was completed in the latter part of August.

Amount available July 1, 1871	$26,186 02
Amount expended during the fiscal year ending June 30, 1872	25,576 56
Amount available July 1, 1872	609 46

No further appropriation is required.
(See Appendix V 4.)

5. *Penobscot River, Maine.*—The navigation of this river is much obstructed by bars and sunken rocks, between Bangor and Crosby's Narrows, about three and a half miles below. These bars are chiefly composed of the "waste" from the saw-mills at Bangor and above, and have been accumulating for more than fifty years. The sunken rocks are all in the harbor of Bangor, and are known as "Independence Rock," "Steamboat Wharf Ledge," "Gulliver's Rock," "Green's Pier Ledge," and others.

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The work done up to the 1st of July, 1871, for the improvement of this river, consisted in the removal of portions of Independence Rock and Steamboat Wharf Ledge, in all about 480 tons.

During the fiscal year ending June 30, 1872, the following additional work was done, viz:

Under a contract made in May, 1871, all the obstructions (with the exception of the ledges) were removed from the channel above Low's Ledge to a width of 200 feet, down to the natural bed of the river; and some progress was made, under the same contract, in the excavation of the "Middle Bar" at Severance Point. This contract also provides for the removal of the "Lower Bar," near Stearn's Mill, and that all the work embraced in it should be done on or before the 30th of September, 1872. On the ledges the additional work is as follows, viz:

1. Removal from steamboat wharf Ledge, about	600 tons.
2. Removal from Independence Rock, about	800 tons.
3. Gulliver's Rock entirely removed, about	80 tons.
4. Green's pier Ledge removal to bed of river, about	115 tons.
Removal during the year, total, about	1,595 tons.

Making the quantity of ledge removed up to July 1, 1872, about 2,075 tons, or about 1,000 cubic yards; leaving yet to be removed about 530 cubic yards.

A contract has been made for completing this work, under the appropriation of June 10, 1872, for the sum of $21,200. The balance of this appropriation will be applied to the still further enlargement of the channels through the bars below Bangor.

The officer in charge states that the throwing of sawdust into the river is still continued to a very great extent, and to the great detriment of its navigation, and suggests as a means of arresting this evil the withholding of appropriations for the improvement of the river until the obstruction of its navigation in this manner shall be prevented by suitable legislation.

Balance available July 1, 1871	$57,440 63
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during the fiscal year ending June 30, 1872	39,781 00
Amount available July 1, 1872	57,659 63
Amount required for the fiscal year ending June 30, 1874	30,000 00

In the estimate for rivers and harbors, submitted through the Treasury Department in September, 1872, the omission of the officer in charge to estimate for the continuance of the work during the next fiscal year was overlooked. It is now submitted.

(See Appendix V 5.)

6. *Kennebec River, Maine.*—The work heretofore done for the improvement of this river has comprised the straightening and deepening of its channel by dredging through the several shoals, and the removal of numerous sunken ledges and bowlders between Richmond and Augusta. This channel is made 100 feet wide, with a depth of 10 feet up to Gardiner, thence 7 feet to Hallowell, and 6½ feet to Augusta, at low tide in the lowest stages of the river.

On the 1st of July, 1871, the progress made in this work was as follows, viz:

The channel was excavated to the required width and depth at Hinckley's Shoal, (between Gardiner and Hallowell;) at Britt's and Gage's Shoals, (above Hallowell;) and at Shepard's Point Shoal and Hallowell Shoal (at Augusta) to a width of 75 feet; and a large number of bowl-

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ders had been removed from the bed of the river between Hallowell and Augusta. During the fiscal year ending June 30, 1872, the channels at Shepard's Point Shoal and Hallowell Shoal were increased to the width of 100 feet, and several very large bowlders were removed from the channels; the sunken rock near Nehumkeg Island was blasted and removed to a depth of over 12 feet at mean low water; and the channel at the "Upper Sands Bar" (between Richmond and Gardiner) was excavated to a width of 100 feet and a depth of 10 feet at mean low water.

Amount available July 1, 1871	$14,740 03
Amount appropriated by act of June 10, 1872	8,000 00
Amount expended during the fiscal year ending June 30, 1872	14,453 50
Amount available July 1, 1872	8,286 53
Amount required (for completing the contemplated improvement of this river) during fiscal year ending June 30, 1874	12,000 00

(See Appendix V 6.)

7. "*Gut*," *opposite Bath, Maine.*—The improvements made at and near this place, up to the 1st of July, 1872, comprise—

1. The removal of Boiler Rock to a depth of 10 feet at mean low water, or 16½ feet at mean high water.

2. The removal to a depth of 9 feet, at mean low water, of the ledge extending from Boiler Rock northward toward the shore.

3. The removal of two wrecks of vessels, lying in mid-channel, above and near "Upper Hell-Gate."

4. Dredging a channel through the bar next above "Upper Hell-Gate," to a width of 100 feet and a depth of 10 feet, at mean low water, or 16½ feet at mean high water.

5. A partial removal of the projecting points of the ledge on the south side of the river, at "Upper Hell-Gate," the object being to enlarge the water-way, and thereby diminish the velocity of the current.

So that the only work which now remains to be done is to complete the removal of the projecting point of the ledge at "the Gate."

Amount available July 1, 1871	$2,937 53
Amount expended during the fiscal year ending June 30, 1872	887 28
Amount available July 1, 1872	2,050 25

No further appropriation is required.

(See Appendix V 7.)

8. *Royals River, Maine.*—The improvement of this river consists in the excavation of a channel at "Gravel Point Bar," to a width of 100 feet and a depth of 5 feet at mean low water, so as to give 14½ feet at ordinary high water up to the head of navigation at the wharves of Yarmouth; and in the removal of several ledges which obstruct navigation below Yarmouth about one and a half miles.

A contract was made in May, 1871, for the dredging required at "Gravel Point Bar," but after many delays and very unsatisfactory progress, the contractor abandoned it about the 1st of November, 1871. Proposals were again invited for the work, and a contract made in March, 1872, for completing it on or before the 15th of September, 1872. On the 15th of August the contract was satisfactorily completed.

Amount available July 1, 1871	$9,818 23
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during the fiscal year ending June 30, 1872	4,477 31
Amount available July 1, 1872	15,340 92

No further appropriation is required.

(See Appendix V 8.)

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9. *Portland Harbor, Maine.*—The work done up to the 1st of July, 1872, for the improvement of this harbor, embraces:

1. The unfinished capping of the breakwater, completed for a length of 733½ feet;

2. A channel dredged through the "Spit," opposite the Grand Trunk railway-wharves, so as to be 100 feet in width at its inner end, and 200 feet at its outer end, with a depth of 20 feet at mean low water; and

3. A channel excavated through the "Middle Ground Bar" to a width of 500 feet, and a depth of 21½ feet at mean low water, giving a depth of 31 feet at ordinary high water into the inner harbor of Portland.

Of this work that done during the year ending June 30, 1872, consists in the enlargement of the channel through the "Middle Ground Bar" for a width of 200 feet.

The improvements still to be made in this harbor and "Back Bay" comprise the completion of the breakwater, and the widening and deepening of the channel in "Back Bay," for which the available balance of the appropriation is deemed sufficient.

Amount available July 1, 1871	$39,649 08
Amount appropriated by act of June 10, 1872	45,000 00
Amount expended during the fiscal year ending June 30, 1872, (including outstanding liabilities)	36,311 34
Amount available July 1, 1872	48,337 74

No further appropriation is recommended to be made at present.

(See Appendix V 9.)

10. *Richmond Island, Maine.*—The improvement contemplated for this place, and for which an appropriation has been made, consists in the building of a rubble-stone breakwater along the shoal which connects this island with the main-land, so as to form a good harbor of refuge, with safe anchorage and good holding-ground during the violent storms from the northward and eastward, when vessels are prevented from entering the harbor of Portland and other ports on this part of the coast. The engineer in charge estimates that the cost of a suitable work will be $80,000.

Amount appropriated by act of June 10, 1872	$20,000 00
Additional amount required for completing the work, all of which could be profitably expended during the fiscal year ending June 30, 1874	60,000 00

(See Appendix V 10.)

11. *Saco River, Maine.*—The work done up to the 1st of July, 1871, consisted in the partial completion of the breakwater at the mouth of the river, to a length of 4,200 feet, in which $72{,}766\frac{380}{2240}$ tons of stone had been placed; also in the removal of the ledges which obstructed the channel near the Little Islands, above "the Narrows." During the fiscal year ending June 30, 1872, the following additional work was done, viz:

1. There were placed upon the breakwater $4{,}008\frac{80}{2240}$ tons of stone, making altogether on the work $76{,}774\frac{460}{2240}$ tons of stone, or $85{,}987\frac{220}{2000}$ net tons.

2. A large iron beacon was placed upon the foot of Cow Island Ledge.

3. A channel was dredged through the bars below the wharves of Saco and Biddeford, to a width of about 50 feet, and to a depth of 5 feet below mean low water in the lowest stages of the river, giving about 14 feet up to these wharves.

The work remaining to be done for the completion of the contemplated improvements in the river is as follows: the repair of the pier at "the Narrows," building a stone pier on Jordan's Point, and im-

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proving the outer end of the breakwater; and for doing this the available funds are sufficient.

Amount available July 1, 1871	$11,910 92
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during fiscal year ending June 30, 1872	11,071 39
Amount available July 1, 1872	15,839 53

No further appropriation is required.

(See Appendix V 11.)

12. *Kennebunk River, Maine.*—The improvement of this river embraces the extension and repair of the two stone piers at its mouth, and the repair of the Government wharf near its mouth. On the 1st of July, 1871, the extension of the eastern pier had been completed for a length of 168 feet, and some repairs had been made upon the old pier itself and upon the Government wharf. Since then the extension of the western pier has been completed for a length of 166⅓ feet, and both of the old piers, as well as the Government wharf, have been repaired to the extent considered necessary.

Amount available July 1, 1871	$5,008 84
Amount expended during the fiscal year ending June 30, 1872	4,666 77
Amount available July 1, 1872	342 07

No further appropriation is required.

(See Appendix V 12.)

13. *Wells Harbor, Maine.*—About forty years ago, a pier made of crib-work, and ballasted with stone, was built at the mouth of this harbor for the purpose of straightening and deepening the channel over the bar. This pier now requires repairs, for which an appropriation was made in the act approved June 10, 1872, amounting to $5,000.

No further appropriation is required.

(See Appendixes V 13 and V 26.)

14. *Cocheco River, New Hampshire.*—The improvement of this river, as contemplated, consists in opening a channel through the ledges and shoals up to the wharves of Dover, so as to have a depth of 4 feet at mean low water, or 10½ feet at ordinary high water, in low stages of the river.

During the fiscal year ending June 30, 1872, a channel was excavated by contract through the ledge at the "Lower Narrows," to a width of 75 feet, and a depth of 4 feet at mean low water; and all the sunken rocks were removed from the river between the "Upper Narrows" and Dover Point, five miles below Dover.

Amount available July 1, 1871	$9,874 33
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	8,938 03
Amount available July 1, 1872	10,936 30
Amount required for the fiscal year ending June 30, 1874, (for completion of the work)	22,000 00

See Appendix V 14.)

15. *Merrimac River, Massachusetts.*—The improvements originally planned for this river were:

1. The removal of obstructions at the Upper and Lower Falls, above Haverhill, Massachusetts.

2. The removal of "Gangeway Rocks," "the Boilers," and the wreck of a coal-vessel in the harbor of Newburyport, Massachusetts.

Of these works, there were completed on July 1, 1871, the removal of 475 cubic yards of material from the channel at the Lower Falls, above Haverhill; and the removal of the wreck, and of main Gangeway Rock,

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and the partial removal of North Gangeway Rock, in the harbor of Newburyport. This work exhausted the appropriation made by act of July 11, 1870. The subsequent appropriations, made by acts of March 3, 1871, and June 10, 1872, were by those acts required to be applied to the improvement of the river above Haverhill; and under a contract made May 31, 1871, 2,100 cubic yards of material were removed from the channel at the Lower Falls. This, together with that previously done, comprises about one-half the work contemplated on these falls.

Amount available July 1, 1871, for the river above Haverhill, Massachusetts	$25,003 66
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during the fiscal year ending June 30, 1872	24,516 64
Amount available July 1, 1872	25,487 02
Amount required for fiscal year ending June 30, 1874	57,000 00
Of which there is required for Newburyport Harbor	22,000 00
And for the river above Haverhill	35,000 00

(See Appendixes V 15 and V 28.)

16. *Gloucester Harbor, Massachusetts.*—An appropriation of $10,000 was made by act of June 10, 1872, for removing rocks in this harbor, which is to be applied to the removal entire of Clam Rock, Pinnacle Rocks, the rock off J. Friend's wharf, and the rock off Pew's wharf, and to the removal of about 375 cubic yards of bowlders from Babson's Ledge. A contract has been made for this work, to be finished in December next.

No further appropriation is asked for.

(See Appendix V 16.)

17. *Boston Harbor, Massachusetts.*—The several works now in progress for the preservation and improvement of this harbor are:

1. The sea-wall for the protection and preservation of Point Allerton;
2. The sea-wall for the preservation and protection of Gallup's Island;
3. The sea-wall for the preservation and protection of Long Island Head;
4. The removal of a part of Kelly's Ledge; and
5. Excavating the channel through the Upper Middle Bar, to a width of 600 feet, and a depth of 23 feet at mean low water.

The progress made upon these works during the fiscal year ending June 30, 1872, was as follows, viz:

1. *Sea-wall on Point Allerton.*—Granite facing, with concrete foundation and backing, an average of 219 linear feet laid; granite coping, 439 linear feet laid; leaving, in order to complete the wall to its contemplated length of 1,230 feet, 541 linear feet of wall to be built, about 5,100 cubic yards of back filling and grading, and 2,050 square yards of paving to be laid.

2. *Sea-wall on Gallup's Island.*—One thousand one hundred and forty square yards of granite paving laid; 51 cubic yards of dry wall built, to concrete the eastern end of the sea-wall with the bank in its rear; and about 300 cubic yards of back filling placed. The sea-wall has thereby been completed to its contemplated length of 1,745 feet, the only work remaining to be done being about 5,000 cubic yards of grading on the bluff in its rear.

3. *Sea-wall on Long Island Head.*—Five hundred and twenty-two and seven-tenths linear feet of granite facing (including concrete foundation and backing) have been built; $822\frac{7}{10}$ linear feet of coping laid; about 2,500 cubic yards of back filling placed. In order to complete this sea-wall to its contemplated length of 2,100 feet, there remain $843\frac{3}{4}$ linear feet of wall (including facing, coping, concrete foundation, and backing)

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to be built; about 5,400 cubic yards of back filling and grading to be done; 3,460 square yards of granite paving to be laid, and 50 cubic yards of dry wall to be built.

4. *Removal of Kelly's Ledge.*—This ledge was removed in 1870, to a general depth of 23 feet below mean low water, leaving only a few projecting points still to be removed.

5. *Dredging on Upper Middle Bar.*—On the 1st of July, 1871, 26,120 cubic yards were excavated by contract; on the 1st of July, 1872, 20,355 cubic yards additional had been excavated, whereby one "cut" 40 feet in width has been excavated through the whole length of the bar, for a distance of 1,800 feet, and a second "cut" has been completed for a length of 1,040 feet. To complete this channel to the contemplated width of 600 feet will require about 230,000 cubic yards additional dredging.

Under the appropriation of June 10, 1872, proposals have been invited for extending the sea-wall on Point Allerton 225 feet, and that on Long Island Head 275 feet, and for dredging on the Upper Middle Bar; and contracts were made in August for the extension of the sea-walls.

For the completion of all the works, to the extent contemplated, it is estimated that there will be required the additional sum of $265,000.

Amount on hand July 1, 1871	$78,644 17
Amount appropriated by act of June 10, 1872	75,000 00
Amount expended during the fiscal year ending June 30, 1872	77,933 76
Amount available July 1, 1872	75,710 41
Amount required for fiscal year ending June 30, 1874	175,000 00

(See Appendix V 17.)

18. *Duxbury Harbor, Massachusetts.*—The improvement contemplated for this harbor embraces the enlarging of Miles Channel to a width of 250 feet with a depth of 8 feet at mean low water, as well as some work for the preservation of Duxbury Beach, the neck of land by which this harbor is sheltered. The estimated cost of this work is $20,000.

Amount appropriated by act of June 10, 1872	$10,000 00
Additional amount required for its completion	10,000 00

The amount now available for this work will be applied to the improvement of Miles Channel, the work to be done by contract, for which proposals have been invited.

(See Appendixes V 18 and V 29.)

19. *Plymouth Harbor, Massachusetts.*—The plan adopted for the preservation of this harbor consists in the construction of brush bulk-head and jettees, which are built of frame-work, filled with brush and ballasted with stone; together with stone bulk-heads in places where most exposed to the action of the sea. This work seems to check the motion of the waves and sand, and to form a new bank, which is eventually enlarged and strengthened by planting beach-grass upon it. Thus far it has been attended with very satisfactory results in this harbor. During the past year the following work was done, viz: 641½ linear feet of brush bulk-head and jettees were built by contract; 2,028 tons of stone were furnished and placed upon the stone bulk-head, by contract; and extensive repairs were made upon the brush bulk-head and jettees along the beach, and beach-grass planted in places where most necessary.

Amount available July 1, 1871	$8,906 51
Amount appropriated by act of June 10, 1872	2,500 00
Amount expended during the fiscal year ending June 30, 1872	8,141 83
Amount available July 1, 1872	3,264 68
Amount required for the fiscal year ending June 30, 1874	3,000 00

(See Appendix V 19.)

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20. *Wellfleet Harbor, Massachusetts.* — Under the appropriation of $5,000 made by act of June 10, 1872, for removing the rocks at the entrance of this harbor, the following rocks are to be removed:

"Channel Rock," "Lobster Rock," "Lumpfish Rock," "Mayo's Rock," and "Bay Rock." A contract has been made for doing the work for the sum of $3,000.

No further appropriation is required.

(See Appendixes V 20 and V 30.)

21. *Provincetown Harbor, Massachusetts.*—The work done during the past year consists in the repairs where most needed, on the bulk-head and jettees on Beach Point; in extending the stone bulk-head on Long Point Beach; in the building of a new substantial dike at Abel Hill, across the head of Lancey's Harbor; and in elaborate current observations in the inner harbor and a resurvey of other parts of the harbor.

Amount available July 1, 1871	$9,029 25
Amount appropriated by act of June 10, 1872	5,000 00
Amount expended during the fiscal year ending June 30, 1872	8,044 82
Amount available July 1, 1872	5,984 43
Amount required for the fiscal year ending June 30, 1874	10,000 00

(See Appendix V. 21.)

22. *Hyannis Harbor, Massachusetts.*—The work of rebuilding the breakwater was carried on during the past year. This breakwater is 1,170 feet in length, of which there had been rebuilt on the 1st of July, 1871, 695 linear feet, and 175 feet of the foundation built up, ready for the top wall. In the month of September, 250 linear feet additional were completed by contract, leaving 225 linear feet of the wall still to be rebuilt. The cost of its completion, as estimated by the engineer in charge, will be $10,000, which amount could be profitably expended during the next fiscal year.

Amount available July 1, 1871	$9,903 50
Amount expended during the fiscal year ending June 30, 1872, leaving no balance on hand	9,903 50
Amount required for the fiscal year ending June 30, 1874	10,000 00

(See Appendix V 22.)

23. *Wareham Harbor, Massachusetts.* — A survey of this harbor made in October, 1871, "with a view to dredging the same and fitting it for a harbor of refuge," showed the existence of two bars in Wareham River, and a sunken ledge and bowlder in Weweantit River, which, uniting with Wareham River, is a continuation of the harbor of Wareham.

Lieutenant-Colonel George Thom, Corps of Engineers, the engineer in charge of the survey, recommends—

1st. That a channel be excavated across Quahaugh Bar to a width of 250 feet, and a depth of 9 feet at mean low water, thereby giving $13\frac{5}{10}$ feet at ordinary high water, at an estimated cost of	$18,567 00
2d. That the present channel below the Franconia Iron-Works be widened and deeped to the same depth, at an estimated cost of	20,385 00
3d. The removal of a sunken bowlder and ledge from the channel of Weweantit River, at an estimated cost of	3,000 00
Add for engineering and contingencies	3,048 00
Total estimated cost of improvement	45,000 00
Amount appropriated by act June 10, 1872	$10,000 00
Amount required for the fiscal year ending June 30, 1874	15,000 00

The improvements herein recommended would enable vessels drawing 12 feet water to ascend to the wharves at Wareham at high tide.

(See Appendixes V 23 and V 31.)

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24. *Taunton River, Massachusetts.*—The improvement of this river, now in progress, consists in the excavation of a channel to a width of 60 feet, and a depth of 4½ feet at mean low water, (or 9 feet at mean high water,) through the several shoals which obstruct its navigation between Dighton and Weir village, a distance of about six miles.

The appropriations heretofore made have been applied to improving the locality known as "The Needles," formerly the most dangerous and difficult part of the river to navigate. Here the channel was completed in November last to the contemplated width and depth, and is now safe and unobstructed for navigation.

Additional amount required to complete the proposed improvement of the river, $30,000, of which $20,000 could be profitably expended thereon during the fiscal year ending June 30, 1874.

Amount available July 1, 1871	$19,392 00
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	19,392 00
Amount available July 1, 1872	10,000 00
Amount required for fiscal year ending June 30, 1874	20,000 00

(See Appendix V 24.)

25. *Edgartown Harbor, Massachusetts.*—A survey of this harbor was made in April last, in compliance with a resolution of the House of Representatives of April 7, 1872, "with a view to dredging and improving the same, so as to afford greater protection and facilities to commerce." This survey showed that the southern channel through Cotamy Beach had been closed during a violent gale about two years since, whereby the tidal currents have been stopped, much to the injury of the harbor. Lieutenant-Colonel Thom, the engineer in charge of this survey, recommended that a channel should be opened through Cotamy Beach, with a view to restoring the former regimen of the currents, and he considers that the most feasible and desirable channel is that which would guide the tidal currents in the shortest and most direct course from Cotamy Point to the ocean. The cost of this channel, excavated to a width of 150 feet and a depth of 4 feet at mean low water, he estimates at $22,000.

Amount appropriated by act of June 10, 1872	$20,000 00

No appropriation for the next fiscal year is recommended.
(See Appendixes V 25 and V 32.)

IMPROVEMENT OF RIVERS IN OREGON.

Officer in charge, Major Henry M. Robert, Corps of Engineers.

1. *Lower Willamette River, Oregon.*—Dredging has been carried on during the past fiscal year at Swan Island Bar, and at the bar at the mouth of the river, with the old dredge-boat belonging to the city of Portland, removing 27,258 cubic yards, at a cost of $47.65 per cubic yard. Many large trees and stumps were removed from the bed of the channel, some of which required the employment of a diver for their removal. The bars were dredged to a depth of 15 feet, and the work of dredging a channel 17 feet deep over Swan Island Bar was resumed. This enabled all vessels, which could get over the bar at Saint Helen's, in the Columbia River, to reach Portland.

Last winter's high water caused a large deposit in and above the cut at Swan Island, the upper part of the bar having been raised about one foot. This adds 17,000 cubic yards of material to former estimates for the completion of the 17-foot cut, which will altogether require the re-

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moval of 25,000 cubic yards of material, and may be completed this present fiscal year.

With the appropriation of $50,000 made for this work June 10, 1872, it is proposed to continue the dredging with the old dredge-boat and apparatus borrowed from the city of Portland, and to build a powerful steam-dredge and scows.

Amount available July 1, 1871	$17,970 20
Amount appropriated June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872	14,115 40
Amount available July 1, 1872	53,854 80
Amount required for fiscal year ending June 30, 1874	20,000 00

Which it is recommended be appropriated for the "improvement of the Willamette and Columbia Rivers, from Portland, Oregon, to the sea," so as to include Saint Helen's Bar, in the Columbia River.

(See Appendix W 1.)

2. *Upper Willamette River, Oregon.*—A "Long's" scraper was constructed and used on two bars with great advantage. A snag-boat was built, with which many of the most dangerous snags between Oregon City and Eola (three miles above Salem) were removed, when the high water stopped work.

A contract for building 2,100 linear feet of dams has been entered into, the dams to be built by October 31, 1872.

The operations during the present fiscal year will comprise building the wing-dams referred to, and clearing the river of snags, and using the scraper where needed.

Amount available July 1, 1871	$16,000 00
Amount expended during the fiscal year ending June 30, 1872	7,746 39
Amount available July 1, 1872	8,253 61
Amount required for the fiscal year ending June 30, 1874	3,000 00

(See Appendix W 2.)

3. *Umpqua River, Oregon.*—The appropriation of $22,500 for the improvement of this river was available July 1, 1871. One thousand nine hundred and eighteen cubic yards of rock were removed, at fifteen different points on the river, between Roseburg and Scottsburg, a distance of one hundred and twenty miles, and a dam, which obstructed the channel, cut away.

The current of the river is so rapid that, with all this improvement to the channel, it cannot be navigated profitably, owing to direct competition with the Oregon and California Railroad. No further work is therefore recommended.

Amount available July 1, 1871	$22,500 00
Amount forfeited, deposit of a bidder	111 00
Amount expended during fiscal year ending June 30, 1872	17,925 11
Balance available	4,685 89

No further appropriation required.

(See Appendix W 3.)

4. *Survey of St. Helen's Bar, Columbia River.*—This survey was made to determine the amount of work which would be required to open a channel through this bar, which of late years has proved very troublesome to the navigation of the Columbia River by the large vessels seeking the port of Portland, Oregon. The survey was made before the spring freshet, and showed a channel of 400 feet width, carrying 16 feet of water at lowest stage, or one foot greater than reported last summer. Five weeks' work of the dredger would probably deepen the channel

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to 18 feet depth. The bar is likely to require some dredging every year.

No separate appropriation is asked for this improvement, as provision for the work has been previously recommended to be made, under the head of "Improvement of the Lower Willamette and Columbia Rivers from Portland, Oregon, to the sea."

(See Appendixes W 4 and W 6.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Robert is charged with the following, directed to be made by the act of June 10, 1872:

1. At Saint Helen's Bar, Columbia River, Oregon.
2. At Port Orford, Oregon.

HARBOR OF SAN DIEGO, CALIFORNIA.

Lieutenant-Colonel B. S. Alexander, Corps of Engineers, having called the attention of this office to the probable filling up of the upper portion of this harbor, he was instructed to direct such observations to be made as might be necessary to determine the extent of this filling and the probable cause thereof.

He reports as the result of this examination that no injurious changes have taken place in the channel of the upper part of the harbor since the survey exhibited in the Coast-Survey chart of 1856.

(See Appendix X.)

BREAKWATER AT WILMINGTON, CALIFORNIA.

Officer in charge, Major G. H. Mendell, Corps of Engineers.

In July, 1871, about 1,400,000 feet of timber were bought for the breakwater. In August a contract was made for the construction of the first section, 3,700 feet in length. The contractor commenced work in the early part of October, and abandoned it on the 6th December, having built 415 feet. The work was resumed in May with hired labor, and by the close of June six steam pile-drivers were employed. This force had completed, on 30th June, 415 feet of the work, and two-thirds of the work necessary to complete 600 feet more.

The work laid out for the season is about 4,100 feet, which will reach a point 2,000 feet from Dead Man's Island. This portion of the breakwater, 2,000 feet in length, it is intended to build of stone alone.

In January over a million feet of timber were bought for the second section of the work.

Amount of appropriation available on July 1, 1871	$199,110 45
Amount of appropriation made June 10, 1872	75,000 00
Amount expended in fiscal year ending June 30, 1872	128,648 98
Balance available July 1, 1872	145,461 47
Amount required for the fiscal year ending June 30, 1874	150,000 00

Which will complete the work, unless unusual and unforeseen difficulties occur.

(See Appendix X.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

Major Mendell is charged with the following, directed to be made by the act of June 10, 1872:

1. At Estero Bay, San Luis Obispo County, California.
2. Of the harbor of San Diego, California.

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IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA.

Officer in charge, Major O. E. Babcock, Corps of Engineers.

The condition of the public reservations in the city, and a detailed statement of the improvements made on them during the fiscal year just closed, will be found in the report of the officer in charge. (Appendix Y.)

Attention is invited to his letter of May 14, 1872, in answer to a resolution of the House of Representatives calling for a list of public reservations in the city, their area, and a detailed statement of the amount necessary to improve part of them. (Appendix Y 1.)

Those amounts are embodied in the estimates for the fiscal year ending June 30, 1874, and, if adopted, will complete the improvement (except fencing) of the entire line of Government reservation from the Capitol to the Executive Mansion, thus connecting them by a park which would be an ornament to the city.

It will be seen that the total area of the public reservations in the city amounts to 340 acres, 1,489 square feet, much of which is vacant and unimproved.

The officer in charge suggests that those reservations on the avenues which are being graded and parked by the city should be first improved, and in a manner suitable to the improvements now being made by the city.

During the last fiscal year there have been laid over 46,000 square feet of sod, 11,738 feet of iron pipe, nearly four miles of drain-tile, 19,285 feet of stone flagging, 1,000 feet of curb, 4,142 square yards asphalt walks, 1,160 square yards of brick pavement, over 3,000 square yards of gravel walks made, and over 26,000 cubic yards of earth removed.

The estimates for the fiscal year ending June 30, 1874, are as follows

For improvement and care of public buildings and grounds	$420,553 00
For compensation to persons employed on and around the public buildings and grounds	47,824 00
Total	468,377 00

(See Appendixes Y and Y 1.)

WASHINGTON AQUEDUCT.

Officer in charge, Major George H. Elliot, Corps of Engineers, until the 13th of October, 1871, and since then Major O. E. Babcock, Corps of Engineers.

The dam at Great Falls remains in good condition. During the low water of the past summer, the balance of the appropriation for removing obstructions above the dam was nearly expended.

During the months of June and July it was necessary, in consequence of low water, to build temporary dams in the Maryland channel, above Conn's Island. As these temporary dams will probably be washed away during the winter freshets, it is recommended that the stone dam be constructed entirely across the river to the Virginia shore.

Cabin John Bridge and Griffith Park Bridge.—The appropriation of $10,000 for completing coping and iron railing was expended in the purchase of stone.

The plan adopted for completing these bridges consists of coping and parapets of solid cut-stone masonry. The work is under contract, and the present appropriation is sufficient to finish Cabin John and to purchase a part of the coping for Griffith Park Bridge.

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The tunnels on the line of the conduit remain in good condition.

The receiving-reservoir.—The balance of the appropriation available for this reservoir is to be expended in constructing wing-walls at the head of the connecting conduit. But it cannot be expended until the completion and filling of the distributing reservoir.

The distributing-reservoir.—The influent and effluent gate-houses have been finished; also the stair-well house. The central gate-house is partly built, and the work is progressing. The slope wall for the protection of the interior facings is nearly done. A cast-iron pipe, 4 feet in diameter, to be laid from the central gate-house to the effluent gate-house has been contracted for and partly finished.

The high-service reservoir in Georgetown has been completed by the construction and erection of an ornamental iron cornice, extending entirely around the domical arch covering the reservoir. On the High street and Road street fronts an ornamental wrought-iron fence has been erected. The District of Columbia 36-inch main has been laid from the distributing-reservoir to the intersection of L street with New Jersey avenue. The 30-inch main of the District of Columbia is laid complete from the terminus of the 36-inch main to the intersection of Massachusetts and New Jersey avenues, and is there connected with the United States 30-inch main.

The District 20-inch main is being laid in North B street on Capitol Hill.

Estimates of the amounts required for the next fiscal year.

For finishing the wooden fence at the distributing-reservoir	$1,500 00
For dwelling for the gate-keeper	2,500 00
For completing stone bridges	8,600 00
For completing the macadamizing of the conduit-road	16,000 00
For engineering, maintenance, and general repairs	15,000 00
For continuing the cut-stone dam across the Virginia channel of the Potomac River	100,000 00
Appropriated for the fiscal year ending July 1, 1872	$114,196 00
Expended during the year	77,496 40
Remaining on hand July 1, 1872	36,699 60

(See Appendix Y.)

SURVEY OF NORTHERN AND NORTHWESTERN LAKES.

Officer in charge, Major C. B. Comstock, Corps of Engineers, who has under his immediate orders the following officers of the Corps of Engineers: Captains W. R. Livermore and A. N. Lee, and Lieutenants Edward Maguire and C. F. Powell, and civil assistants J. R. Mayer, O. B. Wheeler, A. C. Lamson, E. S. Wheeler, G. Y. Wisner, A. R. Flint, G. A. Marr, L. Foote, Henry Custer, and F. M. Towar.

Progress of the work from October 1, 1871, *to July* 1, 1872.—Parties were recalled from the field at or soon after the date up to which the last annual report of operations was brought, October 4, 1871, and, as the appropriation was nearly exhausted, field-operations were not renewed until the new appropriation was available, on the 1st of July last.

A resurvey of the harbor of Sandusky, and a reconnoissance for a triangulation from Milwaukee to Chicago, comprised nearly all the field-work between the dates mentioned.

In the office, during that time, the work of the shore parties the preceding summer was computed and plotted, covering a developed shore-line six hundred and six miles in length.

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The longitude work by telegraph between Detroit, Saint Paul, and Du Luth was reduced.

Chronograph sheets were read off, and clock errors and rates determined for the telegraphic longitude work between Detroit and Battle Mountain and Austin, Nevada.

Reduction of latitude work and longitude work by powder-flashes in Lake Superior has been nearly completed.

Final charts of Isle Royale, Saint Clair River, and No. 1, of Lake Superior, have been completed for the engraver.

The question of tides in Lake Michigan has been re-examined, and Colonel Graham's results confirmed.

Amount expended during fiscal year 1871–'72	$175,000 00
Amount available for fiscal year ending June 30, 1873	175,000 00
Amount required for survey of northern and northwestern lakes for fiscal year ending June 30, 1874; continuation of survey of Lakes Ontario and Michigan, and Detroit River, connecting Lakes Michigan, Huron, and Erie, and construction of maps, and miscellaneous	234,000 00

Balance on June 30, 1873, if any, to be re-appropriated.

Estimate of funds to be appropriated for the survey of the northern and northwestern lakes, for the fiscal year ending June 30, 1874.

Lake Ontario.—To continue triangulation, topography, and hydrography, and construct the maps. Two steamers, two triangulation parties, and four shore parties	$100,000 00
Lake Michigan.—To complete triangulation and line of azimuths, and to make the map. Four triangulation parties and one steamer	60,000 00
For determination of points connecting Lakes Michigan, Huron, and Erie, and for construction of map. Three astronomical parties	30,000 00
Detroit River.—For survey from Lake Saint Clair to Lake Erie, and to construct map. One triangulation and one shore party	10,000 00
Miscellaneous.—Meteorological observations and reductions, $3,000. Transportation of parties, quarters and fuel for officers, $5,000. Office-rent, fuel, stationery and instruments, $5,000. Contingencies, 10 per cent., $21,300	34,300 00
Total	234,300 00

(See Appendix Z.)

SURVEYS AND EXAMINATIONS WITH THE VIEW TO THE IMPROVEMENT OF RIVERS AND HARBORS.

For continuing these examinations and surveys, and to provide for contingencies of works of river and harbor improvement during the fiscal year ending June 30, 1874, an appropriation should be made of $200,000.

RECONNOISSANCES AND EXPLORATIONS.

The officers of the Corps of Engineers on detached duty at the headquarters of general officers commanding divisions and departments have been engaged during the past year in preparing such maps and sketches and making such surveys and reconnoissances as were required by their respective commanding officers.

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Major J. W. Barlow, on duty with the Lieutenat-General of the Army, was employed during July, August, and a part of September of 1871, upon a *reconnoissance in the valley of the Upper Yellowstone River*, a special report of which appears in Executive Document No. 60, Forty-second Congress, second session.

Captain W. A. Jones, on duty with the commanding general Department of the Platte, made a *survey and exploration in the Uintah Mountains of Utah*, during June, July, and August of 1871, a report of which is appended. A proposed expedition into Northern Wyoming by the same officer was suspended on account of the great difficulty of supplying transportation. (See Appendix AA.)

First Lieutenant E. H. Ruffner, on duty with the commanding general Department of the Missouri, in addition to his regular duties as engineer officer, submitted a report on the determination of the difference of longitude between the observatory of the lake survey at Detroit and the observatory at Fort Leavenworth, Kansas. The results of his observations are appended. (See Appendix BB.)

EXPLORATIONS IN NEVADA, UTAH, AND ARIZONA.

Officer in charge, First Lieutenant George M. Wheeler, Corps of Engineers, having under his orders Lieutenant Lockwood, Corps of Engineers, and Lieutenant Lyle, Second Artillery, in the exploration of 1871, and Lieutenants Hoxie and Marshall, Corps of Engineers, in field-work of 1872.

At the commencement of the fiscal year the expedition for 1871 was in rendezvous-camp, near Belmont, Nevada. Examinations by the different parties were continued over extensive areas in Nevada, California, Utah, and Arizona, terminating early in December at Tucson, Arizona, at which point the expedition was disbanded.

The party retained for the office labors proceeded via San Francisco to Washington, D. C., to complete the maps and other data necessary to exhibit the results of the expedition, although many of the records and collections did not reach Washington until late in May. A preliminary map of the area surveyed, and a report explaining the main features of the results, and showing the progress of the work planned for the season, were submitted in March, and have been published by Congress.

The preparation of the more elaborate report and maps, with the accompanying papers on geology, mineralogy, and natural history, was continued until the passage of the requisite appropriation enabled Lieutenant Wheeler to resume field-work.

The present season's operations will extend over portions of Utah, Nevada, and Arizona, and in addition will comprise the careful establishment of a series of astronomical positions, which will form a standard line of reference.

Lieutenant Wheeler submits an estimate for continuing the exploration of $90,000.

(See Appendix DD.)

GEOLOGICAL EXPLORATION ON THE FORTIETH PARALLEL FROM THE SIERRA NEVADA TO THE EASTERN SLOPE OF THE ROCKY MOUNTAINS.

Mr. Clarence King, United States civil engineer, in charge.

The geological and topographical exploration of the territory between the Sierra Nevada and the Rocky Mountains has been continued. Since

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my last report volume v, Botany, has been published, and partially distributed. A third volume is in press.

The present season's work comprehends the completion of field-work of the geological exploration of the fortieth parallel, and an illustrative series of studies of the geology and topography of the extinct volcanoes, and some further studies in glacial action. It is estimated that all the field-work can be completed in the latter part of October, and Mr. King has been authorized upon its completion to resume office-work in the preparation of accumulated results.

ESTIMATES OF AMOUNTS REQUIRED FOR MILITARY AND GEOGRAPHICAL SURVEYS AND RECONNOISSANCES.

For continuing surveys for the defense of the coast, military surveys and reconnoissances in the interior, and geographical and geological explorations, an appropriation of $200,000 will be required.

SUBDIVISION AND SALE OF A PORTION OF THE FORT GRATIOT MILITARY RESERVATION.

The sale of the further subdivision of a portion of this reservation began on the 8th of August, as advertised, and continued until all the lots offered were sold, the aggregate amount realized being $58,433.91, which, added to the amount $41,524, realized at the preceding sale, gives a total of $99,957.91 as the proceeds of the two sales.

A small part of that portion of the reservation set apart for sale still remains unsold, awaiting action by Congress, relative to change of boundaries of the park granted to the city; also action of the city authorities of Port Huron, concerning change of location of cemetery.

An appropriation of $2,000 was made June 10, 1872, under which it is intended to properly lay out the streets and lots.

Amount available July 1, 1871	$559 58
Appropriation of June 10, 1872	2,000 00
	2,559 58
Expended to June 30, 1872	491 90
Amount available July 1, 1872	2,067 68

SUTRO-TUNNEL COMMISSION.

The Sutro-tunnel commission completed their labors and made their report in the early part of last winter. The report was duly submitted to you, with my remarks, on the 4th of January, 1872.

(See Appendix EE.)

MISCELLANEOUS.

The maps of the Atlanta campaign, prepared by Colonel Edward Ruger, late United States Volunteers, have been completed.

My attention having been attracted to certain omissions in published reports and maps of explorations, chiefly respecting the exploration, survey, and opening of important routes of communication by Captain Marcy and Lieutenant Simpson, in 1849, and by Captain Simpson in 1859, the first being the route along the South Fork of the Canadian, between Fort Smith and the Rio Grande, and the second the "overland stage route," across the Great Basin of Utah, I submit herewith a

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communication upon the subject from Colonel J. H. Simpson, Corps of Engineers.

(See Appendix FF.)

OFFICE OF THE CHIEF OF ENGINEERS.

In the labors of the Office I was assisted on the 30th of June by the following officers in charge of the several divisions:

FIRST AND SECOND DIVISIONS.—*Fortifications, battalion and depots, lands, armaments, personnel, &c.*, Major T. L. Casey.

THIRD DIVISION.—*River and harbor improvements, &c.*, Major J. G. Parke.

FOURTH AND FIFTH DIVISIONS.—*Property accounts, estimates, funds, survey of the lakes, explorations, maps, instruments, &c.*, Lieutenant-Colonel J. G. Foster.

During a portion of the year the fourth and fifth divisions were in charge of Major J. B. Wheeler.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General, Chief of Engineers,
Commanding Corps of Engineers.

Hon. WM. W. BELKNAP,
Secretary of War.

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APPENDIX.

APPENDIX A.

ANNUAL REPORT OF MAJOR D. C. HOUSTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Chicago, Illinois, September 2, 1872.

GENERAL: I have the honor to transmit annual reports for the works in my charge for the year ending June 30, 1872.

Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

A 1.

IMPROVEMENT OF DU LUTH HARBOR, MINNESOTA.

The appropriation of $60,000, by the act of Congress of March 3, 1871, has been applied to the extension and repairs of the breakwater built by the railroad company. The total extension is 400 feet, making the total length of the breakwater 950 feet, affording a good protection to the railroad-docks. Captain A. M. Miller, Corps of Engineers, assistant in charge of the work, reports as follows:

> The old portion of the breakwater, that built by the railroad company, was found to be in a very bad condition, requiring considerable repairs. A protection to the exposed or north side was constructed by bolting on, vertically, oak piles capped with oak timber 12 by 6 inches. This protection could not be put on a portion of the work next the shore, owing to its weak and battered condition. This part of the work was protected by a heavy riprapping of large stone, which was found to be a thorough protection against the ice and storms of last winter. It was found that great difficulty was met with in keeping the stone ballast in the superstructure. This was accomplished, however, by laying and bolting 12 by 12 inch timber, six inches apart, over the top of the work.

During the working season, the canal through Minnesota Point, which work is carried on by the city of Du Luth, has been enlarged nearly to the width proposed, viz, 250 feet, and of sufficient depth to allow vessels of all classes to pass through. The dike from Minnesota Point to Rice's Point, which was designed to prevent the diversion of the waters of the Saint Louis River through canal, by which the scour at Superior entry would be reduced, has not yet been completed. The character of the bottom was unfavorable to the construction of the work on the plan adopted, and several breaks occurred after the spring freshets. These have been partially repaired. During the season a careful series of observations have been made upon the currents and water-levels at the canal entry, the mouth of the Saint Louis and Nemadji Rivers, and

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in the lake at Du Luth, for the purpose of ascertaining all the facts bearing on the question of harbor improvements at the head of Lake Superior. The canal at Du Luth was made by that city, and, at the instance of the Government, an injunction was issued prohibiting work on the canal, in the spring of 1871, based upon the ground that such a canal would interfere with the improvements of the "entry" to Superior Bay, which were being carried on by the Government of the United States. This injunction was afterward dissolved, on the condition of constructing a dike as above mentioned. The effect of the canal would be to divert the water-discharge from the Saint Louis River from the natural outlet, and thus diminish the scour of the current at that point, by which the existing channel was maintained, and upon which the Government depended to scour out the channel between the piers when they should be extended over the bar forming the obstruction at the mouth at Superior Bay. From the published correspondence (see Senate Doc. No. 60, Forty-second Congress, second session) it appears that the object of the Government was to prevent any action which might interfere with the prosecution of the work at the "entry." If it should afterward appear, by actual observation, that no serious injury to the "entry" would result from the canal, there would be no necessity for further interference. The result of the examinations which were made in July and August, 1871, showed that no injury had occurred to the "entry," and the observations on currents at the canal and entry, and Saint Louis and Nemadji Rivers, showed conclusively that at the then stage of water in the river, it was impossible that the canal could have any injurious effect, the current at both points depending principally on the variations in the lake-level, and changing constantly in direction and velocity. It has been reported that almost immediately after the cutting of the canal, a remarkable shoaling occurred at the entry, which was ascribed to the effect of the canal; but this report is accompanied by the statement that "no storm occurred in those three days to assist in shoaling the water." This is reported by a resident of Superior City, in a letter dated June 26, 1871. Captain A. M. Miller, of the Corps of Engineers, reported to me, in a letter of the same date, as follows: "There have been no storms to raise the bar, or freshets to bring down material for a deposit." Now, if there was neither a deposit from the river nor a storm to affect the bar, I do not see where the material which was necessary to cause shoal water could have come from. The canal could not have brought the material to the entry. If there had been a storm to affect the bar at the time referred to, it would have been proper to have inferred that the strength of the current at the entry had been so reduced by the diversion of water to the canal that it was insufficient to counteract the effect of the storm. If there was no sediment deposited from the river, and no action of the waves to affect the bottom, there could have been no shoaling unless by an upheaval of the bottom, which could hardly have been caused by the canal.

Finding by our surveys that no shoaling had occurred, and being satisfied that none would occur during the low-water season which could be ascribed to the canal, and knowing at the same time that when the piers were extended out over the bar into deep water, the action of the waves and lake-currents in forming bars would be to a great extent arrested, I recommended a postponement of the construction of the dike until after the spring freshets of the present season, feeling that *in a single season* very little, if any, injury would occur at the entry, and that we might find the dike unnecessary. A great inconvenience and expense would thus be avoided, and the wishes of all

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parties gratified. A study of the subject, based on personal examinations and careful observations, made continuously since June, 1872, has confirmed this view, and as the subject has given rise to extensive correspondence and criticism, I take this occasion to explain more fully than heretofore the reason for this opinion. I would first state that in the fall of 1870, and in the spring of 1871, I expressed very strong opinions as to the injurious effects of the canal upon the entry, based upon the information at that time in my possession. The plan of improving the entry by constructing parallel piers and confining the current, looked to the scour of the Saint Louis River to clear out the channel, and the natural channel depended, and would depend, almost entirely on this scour, until the improvements were advanced nearly to completion.

At the time the canal was commenced, and in the spring of 1871, the entry-channel was practically in its natural state, and depended on the scour of the current. The bar was well in advance of the piers, and subject to the influence of storms. If the current at that time had been sufficiently reduced by the canal, and a series of northeast storms occurred, as frequently happens, there was every reason to believe that serious injury would occur to the entry. This combination of circumstances did not take place.

The work on the canal was not pushed as rapidly as was possible, and the current at the entry was sufficient to maintain the depth on the bar. The piers at the entry were being pushed forward, so that it was probable that they would be in 12 feet of water by the close of the season. The bar at the mouth of Superior Bay is composed of sand and gravel, and its formation is due solely to the action of the lake. The material brought down by the current, mainly from the Nemadji River, is not found on the bar. It is carried out by the current and diffused by the action of the waves. The natural channel over the bar is produced and maintained by the current.

Now, the effect of storms is to form a continuous beach. The waves stir up the material composing the bottom to a certain depth, and, when they strike the shore obliquely, a littoral current is produced, which carries the sand and gravel along the shore, and deposits it in any inlet where there is not sufficient current to move it. If the mouth of a river or harbor is met with where there is a strong ebb-current, this material is carried out and deposited in the lake as soon as the velocity is sufficiently reduced, forming the bar.

There is a certain depth beyond which waves cease to disturb the bottom, which may be assumed practically at 18 or 20 feet. If piers at the mouth of the harbor are extended out to this depth, the action of storms in forming a bar is stopped, and if a channel is excavated to the same depth below the action of the waves, there is nothing to fill it up except the deposits brought down by the river. Hence, having once formed a harbor-entrance satisfying the above condition, a river-current, especially when loaded with sediment, becomes an injury, and we find that the finest natural harbors are not the mouths of rivers, but bays, the mouths of which are scoured by tidal flow.

In case the prevailing storms are oblique to the direction of the shore, and in one direction, there will be an accretion on one side of the harbor which renders it necessary to extend the piers from time to time. The northeast storms at Superior are almost directly on shore, and I anticipate that the accretion will be slow, as compared with many points.

In support of the foregoing views I quote from Mr. David Stevenson,

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F. R. S. E., an eminent authority on harbors, as to the formation of bars, found in the Encyclopædia Britannica:

> The following are the conditions under which such accumulations are formed:
> 1st. The presence of sand or shingle or other easily moved material;
> 2d. Water of a depth so limited that the waves during storms may act on the bottom; and
> 3d. Such an exposure as shall allow of waves being generated of sufficient size to operate on the submerged materials.

These conditions cease to exist when the piers are extended out to deep water, and the channel between them excavated to a certain depth.

The inner harbor at Du Luth, if the dike is completed so as to stop the current from the Saint Louis River, will furnish an example of a harbor without any river emptying into it. The dike has had the effect this spring to reduce very materially the current from the river to the canal, at one time a difference of level of three inches having been observed.

When the Saint Louis River was high, the current at the canal was continuously outward; but as soon as it fell, the direction of the current commenced to change in the same manner as observed last season. A survey is now in progress at the request of his excellency C. C. Washburn, governor of Wisconsin, under the direction of W. H. Newton, civil engineer, appointed by him and myself for the purpose of determining what changes have occurred in the Bay of Superior, the entry, and the shore-line of Minnesota Point, since the opening of the canal.

The appropriation of $50,000 by the act of Congress of June 10, 1872, will be applied to the further extension of the breakwater about 300 feet, and still further protection will be given to the work near the shore. It is not considered necessary to extend this breakwater any further, as all the requirements of commerce at Du Luth will be met by the inner harbor and canal. Should it be decided to continue this work the sum of $50,000 is estimated for the fiscal year ending June 30, 1874.

To extend this breakwater so as to cover the mouth of the canal, as has been suggested, will require a further extension of 2,500 feet, at an estimated cost of $400,000. I do not see the necessity for such extension.

The canal, when the piers are extended out to a sufficient distance, will afford an easy and direct entrance to the inner harbor, which is now being excavated by the Northern Pacific Railroad Company, and where they are also constructing extensive wharves and slips.

The following statistics of commerce of the port of Du Luth for the year ending June 30, 1872, are appended:

Arrivals and departures of vessels.

Entered from foreign ports	21
Entered from coastwise ports	241
Total	262
Cleared for foreign ports	22
Cleared for coastwise ports	261
Total	283

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Receipts of merchandise from domestic ports.

Articles.		Quantity.
Dry-goods	pounds	400,040
Hardware	do	2,109,452
Iron bar, bundles and sheets	do	3,130,348
Butter	do	2,235
Lard	do	780
Railroad-iron	do	55,215,008
Railroad-spikes	do	1,247,651
Railroad splices and bolts	do	1,793,634
Coal	do	27,009,520
Pig-iron	do	1,174,268
Sundries	do	4,260,162
Liquor	barrels	637
Salt	do	35,512
Coffee	sacks	4,044
Rice	do	619
Flour	barrels	646
Tin-plate	pounds	291,796
Stoves	number	1,404
Dried fruit	pounds	207,951
Grindstones	number	4,535
Window-glass	boxes	3,372
Resin	barrels	201
Garden-seed	boxes	339
Tan-bark	cords	130
Plaster	barrels	60
Boots and shoes	pounds	26,650
Live stock	head	214
Corn, feed, and oats	pounds	173,700
Crockery	do	56,000
Doors and sash	do	66,400
Furniture	do	62,165
General merchandise	do	429,557
Groceries	do	1,025,280
Hay	do	197,800
Lime	barrels	1,034
Lumber	feet	127,000
Machinery	pounds	97,120
Shingles	M	372
Tobacco	pounds	32,620
Oil	barrels	5,645
Apples	do	2,939
Salt fish	packages	5,776
Sugar	do	18,081
Cement	barrels	2,029
Pork	do	1,076
Beef	do	150
Malt-liquors	packages	860
Vinegar	barrels	284
Nails	kegs	15,777
Molasses	packages	3,863
Tea	half chests	487

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Receipts of merchandise from foreign ports.

Articles.	Quantity.	Value.
Groceries.....packages..	271	$7,411
Tin-ware.....do....	11	300
Pipes.....do....	8	102
Garden-seed.....case..	1	31
Books.....case..	17	707
Liquors.....do....	153	3,585
Earthenware.....packages..	7	124
China-ware.....do....	1	37
Confectionery.....do....	30	447
Tobacco.....cases..	118	3,695
Live stock.....head..	117	10,076
Wagons.....do....	72	5,148
Harness.....sets..	42	1,727
Machinery.....do....	235	13,272
Glass-ware.....cases..	33	1,093
Rope.....packages..	9	292
Gunpowder.....cases..	4	25
Drugs.....do....	12	302
Crockery.....do....	18	989
Stationery.....do....	2	44
Carriages.....do....	31	2,270
Paints.....packages..	16	217
Glass.....boxes..	23	148
Bags.....bales..	6	216
Salt.....packages..	303	129
Leather.....do....	4	297
Furniture.....do....	413	9,128
Musical instruments.....do....	7	2,714
Plated ware.....do....	6	509
Oil-cloth.....cases..	5	721
Toys.....do....	5	254
Jewelry.....packages..	55	83
Dry-goods.....do....	158	12,799
Hardware.....cases..	243	7,370
Clothing.....do..	36	3,484
Boots and shoes.....do..	35	1,603

Shipments of merchandise.

Articles.	Quantity.
Wheat.....bushels..	1,420,254
Barley.....do....	38,502
Oats.....do....	640
Flour.....barrels..	164,114
Mill-feed.....pounds..	875,688
Butter.....pounds..	60,691
Pork.....barrels..	153
Rags.....pounds..	198,320
Salt fish.....packages..	187
Cattle.....head..	18
Scrap-iron.....pounds..	93,550
Scrap-copper.....do....	4,370
Tallow.....do....	18,350
Grass-seed.....do....	20,000
Dressed hogs	44
General merchandise.....pounds..	331,505

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Amount available July 1, 1871	$60,000 00
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872, including $4,848.23 retained from payments to contractors	55,934 72
Amount available July 1, 1872	54,065 28
Amount required for fiscal year ending June 30, 1874	50,000 00

A 2.

IMPROVEMENT OF SUPERIOR CITY HARBOR, WISCONSIN.

The following is an extract from the report of Captain A. M. Miller, Corps of Engineers, assistant in charge of the work:

During the year ending June 30, 1872, there have been placed in position, on the Minnesota pier, twenty-four cribs, 32 feet long and 20 feet wide, and of a height depending upon the depth of water in which they were sunk, making an extension of the Minnesota pier of 768 feet. The work on the Wisconsin pier consisted in the placing of thirty-seven cribs, 32 feet long. These cribs were well placed, and built to an average height of 1 foot above the water-surface. No superstructure has been built on the Minnesota or on the Wisconsin pier. Total extension of the Wisconsin pier 1,184 feet. These extensions of the piers carry the Minnesota pier out to 14 feet depth of water, and the Wisconsin pier to within about 200 feet of the outside 9-foot curve of the bar. During the extension of the Minnesota pier the steamboat-channel was crossed, the pier having been carried across the channel and bar; this caused a deflection of the channel toward the Wisconsin side, and a new channel of 9 feet of water was formed. This latter channel in turn was crossed and closed by the Wisconsin pier, so that at the close of the work last fall the only entrance was directly across the bar, over which not more than 8½ feet could be carried. During the month of May, 1872, there was built under your supervision a scraper, which has been most successful in its operations, the bar having been scraped down to a depth of 10 feet on the Minnesota side, so that vessels drawing 10 feet of water can now enter in smooth weather; this can be increased to a depth of 12 feet by using the scraper. The appropriation for the coming year is $50,000; this is estimated to extend the piers to a depth of 18 feet, practically completing the work. During July, 1871, a survey of the entry was made, and a tracing forwarded. In August, simultaneous current observations were taken at the entry, Du Luth Canal, and Saint Louis and Nemadji Rivers, the tabulated results of which were forwarded.

Very respectfully, your obedient servant,

A. M. MILLER,
Captain Corps of Engineers.

It is proposed to apply the appropriation of $50,000 by act of June 10, 1872, to the extension of the piers, and to excavating a channel between them, as originally designed in case it should be found necessary. The deepening of the channel this season, by the action of the current, makes it probable that no dredging will be necessary. It is thought that the present appropriation will extend the piers up to water-surface as far as necessary. The total appropriation for this harbor, including that of June 10, 1872, amounts to $255,000.

The original estimate (see report of Chief of Engineers for 1867, page 62) was $309,716, leaving a difference of $54,716.

The work remaining to be done after the extension of the piers is the superstructure over all the Wisconsin pier and most of the Minnesota pier, about 3,800 feet of pier in all, for which I estimate about $40,000 for the year ending June 30, 1874.

In case dredging is necessary, the sum of $10,000 additional will suffice.

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The arrivals and departures at the port of Superior, during the year, are as follows:

ARRIVALS.	DEPARTURES.
1871.	
June 30.—*Propeller Cuyahoga.*	*Propeller Cuyahoga.*
140 packages general merchandise.....11,906 pounds.	
July 15.—*Propeller Cuyahoga.*	*Propeller Cuyahoga.*
20 barrels hams .....5,255 pounds.	15 pieces household goods.
35 barrels flour .....7,700 pounds.	34 pieces household goods.
15 firkins butter .....1,120 pounds.	27 pieces household goods.
10 boxes cheese ..... 600 pounds.	503 packages fish.
18 packages general merchandise.....3,500 pounds.	13 packages general merchandise.
5 barrels pork.....1,600 pounds.	
5 tons hay.	
July 18—*Propeller City of Madison.*	*Propeller City of Madison.*
17 packages hardware... 1,455 pounds.	
18 packages crackers.... 1,040 pounds.	
July 29.—*Propeller Cuyahoga.*	*Propeller Cuyahoga.*
29 packages general merchandise..... 2,850 pounds.	87 packages fish.
12 bags corn..... 1,495 pounds.	3 fire-proof safes.
7 barrels ale..... 1,250 pounds.	
August 3.—*Propeller City of Madison.*	*Propeller City of Madison.*
8 packages hardware... 400 pounds.	4 packages general merchandise.
25 barrels flour..... 5,400 pounds.	82 packages fish.
17 packages general merchandise..... 1,560 pounds.	
10¼ tons hay.	
August 13.—*Propeller Cuyahoga.*	*Propeller Cuyahoga.*
10 packages general merchandise..... 1,220 pounds.	10 packages household goods.
20 bags corn..... 2,480 pounds.	1 wagon.
August 27.—*Propeller Cuyahoga.*	*Propeller Cuyahoga.*
83 bags corn-meal ..... 9,300 pounds.	21 packages fish-nets, &c.
54 packages general merchandise..... 5,100 pounds.	16 beer-barrels.
10 packages hardware... 850 pounds.	7 packages household goods.
	4 barrels fish-oil.
	65 iron bolts, 775 pounds.
	500 brick.
October 17.—*Propeller Cuyahoga.*	*Propeller Cuyahoga.*
24 packages general merchandise..... 4,299 pounds.	9 packages household goods.
4 packages hardware... 500 pounds.	2,315 pounds rope.
38 stoves..... 3,260 pounds.	5 barrels potatoes.
10 boxes lard..... 750 pounds.	10 packages general merchandise.
250 sacks ground feed.....33,345 pounds.	
93 packages general merchandise.....14,049 pounds.	
1872.	
May 25.—*Propeller Cuyahoga.*	*Propeller Cuyahoga.*
12 packages general merchandise..... 1,580 pounds.	10 tons hardware.
25 bags corn..... 2,980 pounds.	10 packages general merchandise.
25 burlaps oats..... 3,175 pounds.	4 tables.
47 barrels lime.	7 sacks feed, 800 pounds.
	1 wagon.

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Amount available July 1, 1871	$89,208 90
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during fiscal year ending June 30, 1872, including $4,759.58 retained from payment to contractors	80,822 17
Amount available July 1, 1872	58,386 73
Amount required for fiscal year ending June 30, 1874	40,000 00

A 3.

IMPROVEMENT OF ONTONAGON HARBOR, MICHIGAN.

The last appropriation for this harbor was made July 11, 1870, and amounted to $10,000. This was expended in extending the west pier a distance of 224 feet. The completion of this improvement contemplates the extension of the pier out to a depth of 18 feet of water, at an estimated cost of about $200,000.

At present there is a channel at the entrance, of 11 feet. The locality renders this an important harbor for the safety of commerce, though the local commerce for a few years past has been small.

I am informed that active operations have been resumed at the copper mines, which form the basis of all business at this locality.

In this case it would seem proper that the work of improving the harbor should be resumed, and I therefore submit an estimate of $50,000 to be applied to pier-extension.

The total arrivals of vessels at the port of Ontonagon during the year were 64, and 1,158 tons of freight received. Total departures 64, and 1,132 tons of freight shipped.

Amount available July 1, 1871	$14,059 96
Amount expended during the fiscal year ending June 30, 1872	13,506 74
Amount available July 1, 1872	553 22
Amount required for fiscal year ending June 30, 1874	50,000 00

A 4.

IMPROVEMENT OF EAGLE HARBOR, MICHIGAN.

No work has been done at this harbor during the year, and, as stated in the last annual report, the work has been suspended, it being deemed advisable to await the results of the operations for removing rock obstructions in Hell-Gate, East River, New York, before deciding upon a plan for prosecuting this work.

Amount available July 1, 1871, reported in last annual report	$23,556 57
Above report in error	1,501 11
Amount expended during the fiscal year ending June 30, 1872	249 00
Amount available July 1, 1872	24,808 68

A 5.

IMPROVEMENT OF MARQUETTE HARBOR, MICHIGAN.

The operations for the year ending June 30, 1872, have consisted in extending the breakwater a distance of 550 feet to water-surface, and covering 300 feet of previous work with superstructure. The total

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length of the breakwater is 1,760 feet. It is anticipated that with the $50,000 appropriated by the act of June 10, 1872, the breakwater can be extended 250 feet, including superstructure over all. This will make the breakwater 2,010 feet in length, or 10 feet longer than contemplated in the original estimate of Colonel Raynolds, Corp of Engineers. The original estimate was $279,764. There has been appropriated $240,000. It is not proposed to extend this work any further at present, but to complete it by a substantial covering and protection at the end against collision. For this purpose the sum of $15,000 is estimated.

Should the commerce of Marquette in the future require it, further protection can be afforded by another breakwater, commencing at a point 500 or 600 feet southwest of the end of the present work, and extending in a southwesterly direction toward the shore. Such protection is not deemed necessary at present.

Imports and exports, arrivals and clearances, at Marquette Harbor, during the fiscal year ending June 30, 1872.

IMPORTS.

Coal, tons	50 000
Dry goods and groceries	$250,000
Drugs and chemicals	$150,000
Grain, bushels	300,000
Hay, tons	3,000
Hardware, tons	3,000
Liquors, cigars, and tobacco	$200,000

EXPORTS.

Iron-ore, tons	350,000
Iron, pig, tons	31,606
Sandstone, (dimensions) tons	5,000
Coin duties, (collections)	$69,715 10
Currency:	
Tonnage-tax	616 07
Hospital-tax	539 50
Steamboat-inspection fees	2,037 89
Fees miscellaneous	2,810 10

	No.	Tonnage.
American vessels entered and cleared	776	367,614
Foreign vessels entered and cleared	4	1,488
	780	369,102

Amount available July 1, 1872	$85,017 91
Amount appropriated by act June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872, including $4,036.23 retained from payments to contractors	68,704 65
Amount available July 1, 1872	66,313 26
Amount required for fiscal year ending June 30, 1874	15,000 00

A 6.

IMPROVEMENT OF MENOMONEE HARBOR, MICHIGAN AND WISCONSIN.

Captain J. W. Cuyler, Corps of Engineers, assistant in charge, reports the operations for the fiscal year ending June 30, 1872, as follows:

* * * * * * *

The fiscal year ending June 30, 1872, was the initial year of the work of harbor-improvements at this point. In accordance with the plan of improvement adopted for the expenditure of this first appropriation, a pile-pier 14 feet wide was started last sea-

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son, south of the mid-line of the water-way and just about abreast of the point forming the north side of the *embouchure* of the river; this pier was built outwards and inwards, 1,150 feet in length, 606 feet east, and 544 feet west of starting-point, when winter closed further operations for the season. The work of the present season, to July 1, has been that of putting in a state of completion and security the work constructed during 1871, which has been accomplished and the existing contract closed.

In the progress of the work difficulty was experienced in the driving of the piles, owing to the nature of the bottom—a bed of very hard, compact sand, of considerable depth—and it was only by the exercise of watchfulness and care that the piles were driven the prescribed depth, of from 12 feet to 14 feet, and neat and substantial work attained.

The contractor, Mr. A. Kirby, of Chicago, Illinois, has prosecuted his work with energy and success, and had it not been for the great fires of last October, throughout this section of country, which necessitated an active suspension of operations for a fortnight, and the unusually early setting in of winter weather, a longer line of pier, by 50 feet, would have been built, and an earlier completion of the whole work secured. From an examination of the harbor made in May, just past, the effect of the improvement, as it is at present carried out, seems to have been to carry the "bar" that stretched almost entirely across the *embouchure* out beyond the present eastern end of the pier, giving to the same a slightly increased width, and diminished depth of water over it; the latter, however, being more than compensated for, by the relatively lower stage of water everywhere prevailing on the lakes this season. At same time, due to the relative positions of the pier and main current of the stream, a large proportion of the water passes out, through the gap of 400 feet, between the west end of the pier and the shore dock-line, the freshet of the spring—not so great an one as usual—cutting out here a very deep, though narrow trench, requiring the protecting of this portion of the pier by a heavy riprap. This "gap" private parties propose, in their own interests, to close up the present summer. This done, with the extension of the present pier 400 feet eastward, and the construction of the work on the north side of river-mouth, in accordance with the approved-of "project" for next fiscal year ending June 30, 1873, all of which work will be put under contract, and a half of it, it is anticipated, built the present working season, it is believed that the river-waters will be confined and the force of the current used to cut out a channel-way across the present "bar" between the proposed piers.

Respectfully submitted.

JAS. W. CUYLER,
Captain Engineers, United States Army.

The maximum force of freshets at this locality has not been observed since the Government commenced its operations, according to the reports of citizens, and as the plan of improvement contemplates confining the current at the mouth of the river over the bar by two parallel piers, they will be placed 400 feet apart. It is not considered safe by the citizens to reduce this width. Should future observation show that it can be reduced with safety, it will be done by converging the piers as they are extended.

The completion of this improvement requires the extension of the piers to a depth of 14 feet of water—1,400 feet of pier in all.

If the style of pier now being constructed will answer the purpose, and this fact can only be ascertained as the work progresses, an additional sum of $50,000 will be required. It may also be necessary to do some dredging, but this will depend upon the action of the current. The sum of $50,000 is therefore asked for this harbor.

The following are the total arrivals and departures at Menomonee Harbor during the year, of steamers and sailing-vessels:

Arrivals.—Number, 983; tonnage, 358,863.

Departures.—Number, 1,027; tonnage, 378,435.

Value of cargoes.—Exports, $1,233,269.37; imports, $1,113,940.23.

Amount available July 1, 1871	$24,772 50
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during the fiscal year ending June 30, 1872, including $1,956.54 retained from payments to contractors	22,150 98
Amount available July 1, 1872	27,621 52
Amount required for fiscal year ending June 30, 1874	50,000 00

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A 7.

IMPROVEMENT OF GREEN BAY HARBOR, WISCONSIN.

Captain J. W. Cuyler, Corps of Engineers, assistant in charge, reports as follows:

The operations of the fiscal year just closed have been those indicated in the last annual report, that is, under the same working arrangements as were reported in that report. The proposed channel to the north of "Grassy Island Cut," 60 feet width on west side, has been dredged to 14 feet depth for about 1,000 feet toward Point au Sable, or as far as it was found necessary, from the depth of water, to carry it.

To the south of the "cut" the channel has been dredged out to the full 14-feet depth, 160 feet wide, from the west line of same, throughout the whole length of the section extending south from the first angle of the prolongation (inward) of the lines of the "cut" to the mouth proper, so called in the original plan of improvement devised for this harbor of the Fox River, and as far as this plan contemplated the carrying the dredging, as at this point the deep water of the river is met and a clearly-defined natural channel exists.

To complete now the modified original plan of improvement there remains but to widen, 40 feet to the east, the 160-foot channel above described, dredging out from 2 feet to 9 inches to get the 14-feet depth.

The length of this 160-foot channel, completed last working season, is close on to a mile. The channel, extending north to the "cut" from the north end of this 160-foot dredging, was completed, at the date of the last annual report, the full depth, 14 feet, and width, 200 feet, for its length, three-quarters of a mile.

There thus exists now a channel-way from the Fox River mouth to the "cut," 200 feet wide almost the entire distance, by 14 feet deep.

The repairs to the revetment of the "cut," referred to in last annual report, have all been made, giving a very substantial piece of work, and the riprap protection along the north shore of "Grassy Island," on either side of the revetment, increased and heightened.

This work, together with the dredging, was all completed with the last working season's close.

No work has been done the present working season so far, nor is it in contemplation to do any, the present commercial requirements being met by the improvement in its present state of completion, and the available funds being exhausted.

The character of the dredging last season continued the same as heretofore, neither *very* hard nor *very* soft. The expense of dredging was largely enhanced from the reason of frequent moves on the part of the machine, the cutting being all light, rather leveling off than cutting, indeed. A survey made from the ice last winter reveals no filling in of the dredged channels, the protection given by "Grassy Island" effectively covering these, and preventing changes of the water-way.

Respectfully submitted.

JAS. W. CUYLER,
Captain Engineers, United States Army.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wisconsin July 13, 1872.

Notwithstanding the fact that a 14-foot channel was obtained last season, the variations in the water-level are so great at this locality that vessels are reported as grounding in the channel occasionally.

The observations last season showed an extreme variation in the water-level of 5 feet 5 inches. Sudden changes in the water-level occur, rendering it exceedingly difficult to obtain a perfectly level bottom by dredging.

The present and prospective importance of this harbor is so great that it is deemed advisable to continue the improvement of the channel to such a width and depth that vessels drawing 13 feet of water can pass through at all times and seasons without interruption. To accomplish this, and to make a straight channel from the "cut" to the mouth of the Fox River, will require the removal of about 175,000 yards of material. This estimate is based on an accurate survey made through the ice last winter.

The sum of $50,000 is estimated for this purpose. A smaller sum, however, can be applied with great benefit to the channel.

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For information concerning the commerce of Green Bay, I respectfully refer to the following letter from the deputy collector of customs:

UNITED STATES CUSTOM-HOUSE,
Green Bay, Wisconsin, July 29, 1872.

SIR: Your letter of inquiry in regard to the number of vessels arriving and departing the port of Green Bay, Wisconsin, also the tonnage thereof, was referred to the undersigned, and which I herewith duly answer.

Vessels arrived between July 1, 1871, and June 30, 1872	629
Vessels departed between July 1, 1871, and June 30, 1872	632
Tonnage—vessels arrived between July 1, 1871, and June 30, 1872	146,230
Tonnage—vessels departed between July 1, 1871, and June 30, 1872	146,600

Respectfully yours,

JOHN P. DENSIMAN,
Deputy Collector of Customs.

D. C. HOUSTON,
Major of Engineers, Brevet Colonel United States Army, Chicago.

Amount available July 1, 1871	$19,316 79
Amount expended during the fiscal year ending June 30, 1872	18,856 02
Amount available July 1, 1872	460 77
Amount required for fiscal year ending June 30, 1874	25,000 00

A 8.

IMPROVEMENT OF AHNEPEE HARBOR, WISCONSIN.

Captain J. W. Cuyler, Corps of Engineers, assistant in charge, reports the operations of the year as follows:

The plan of improvement adopted for this harbor looked to the making of an outer harbor here, and in accordance with this plan the funds, the first allotted for harbor purposes at this point, were devoted to the taking of the preparatory steps necessary to carry out the general plan. These steps have consisted in the construction of two parallel pile-piers, each 14 feet wide, on each side of the river-outlet, with 230 feet of water-way between them.

The last annual report contemplated the construction of one pier on the north side only, extending this out for a length of 600 feet. December 2, 1871, when the season's operations closed, this pier had been carried out complete, except in details of finishing up, 352 feet, or to 10 feet water. It was then decided that the operations of the present season should be those of the construction of a parallel pile-pier, on south side of mouth, of equal length as the other pier, in lieu of carrying forward what was at first contemplated.

This change of plan has accordingly been carried into effect this spring, and by July 1, 1872, 140 feet of this new pier had been piled out. The time of the contractors having been extended to August 1, 1872, they propose to, by that date, finish and extend this new pier to a length of 200 feet entire, and complete the unfinished work of last season's pier so as to exhaust the appropriation.

The contractors for this harbor have not carried on the work successfully, or as was expected when the last annual report was written. Many causes, due altogether to themselves, have united to retard their efforts and seriously interfere with the proper advancement of the work.

While difficulties have been here met with more than at any other point where initial measures of harbor-improvement have been instituted, and where this kind of construction has been used, yet the comparison with all these other points does not afford a favorable reflex. The place is inaccessible and poor, open to wind and sea, with a bottom of coarse shingle, interspersed with bowlders overlaying a bed of sand, coarse and hard, itself of no great depth, over solid rock, which, when the 8-foot curve was attained by the north pier, outcropped to within 10 feet of lake-bed, preventing the further penetration of the piles. Such a *locale* was, of course, unfavorable to this class of construction, making it very difficult to drive the piles at all, impossible to so drive them as to maintain work of neat and workmanlike appearance.

It is believed that, now, most of the difficulties in the way, at this point, have been overcome, that the "ridge" of the rock-stratum has been passed, and that the driving will prove easier and better in the further continuance of the piers.

It is proposed this season, under the new contract about to be entered into, to extend

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these pile-piers to 12 feet water, about 100 feet on north and 200 feet on south pier and get a channel of from 10 feet to 12 feet dredged, between piers, for a width of 100 feet, thus opening the river-mouth effectually, and preparing for the work of the future.

Respectfully submitted.

JAS. W. CUYLER,
Captain Engineers, United States Army.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wisconsin, July 16, 1872.

The result of the past and this season's operations, it is anticipated, will be to open the mouth of the river, so as to accommodate all local commerce, and enable future operations of any character to be carried on with more facility.

The plan recommended by me for this harbor originally was an outside basin, which would not only serve the local wants, but afford a harbor of refuge on a portion of the coast where there are no harbors. This is discussed in my report, (see Report of Chief of Engineers for 1871, page 125.) The estimate for such a harbor was $370,000. The work now done and to be done during the present fiscal year is a necessary preliminary as well as a part of this plan. The sum of $50,000 can be advantageously expended at this locality next season, and I submit this estimate for the next fiscal year.

The number of vessels of all classes arriving and departing at the harbor of Ahnepee during year ending June 30, 1872, was 293.

Exports during year.—Railroad-ties, (number,) 116,807; posts, (number,) 122,267; wood, (cords,) 4,280; bark, (cords,) 3,887; telegraph-poles, (number,) 1,986; timber, (feet, board-measure,) 1,119,000; shingles, (number,) 3,075,000; fish, (packages,) 300.

Imports during year.—General merchandise, (barrels,) 10,500; hay, grain, &c., (tons,) 1,500; relief-goods, (tons,) 2,000.

The commerce of Ahnepee for the year was much damaged by the fires that swept the surrounding country in October, 1871.

Among the items of imports will be observed 2,000 tons of relief-goods received for the relief of the sufferers by the fire.

Amount available July 1, 1872	$24,830 60
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during fiscal year ending June 30, 1872, including $962.82 retained from payments to contractors	13,028 10
Amount available July 1, 1872	36,802 50
Amount required for fiscal year ending June 30, 1874	50,000 00

A 9.

IMPROVEMENT OF TWO RIVERS HARBOR, WISCONSIN.

The assistant in charge, Captain J. W. Cuyler, Corps of Engineers, reports the operations of the year as follows:

In accordance with the approved plan of improvement for this harbor, the first appropriation given has been expended during this fiscal year in the construction of two parallel pile-piers, each 14 feet in width, on the east and west sides of the mouth of the Two Rivers.

Both piers have been built out into the lake 416 feet, and under the contract entered into with R. A. Conolly, of Chicago, Illinois, of date June 15, 1871, both were completed substantially December 16, 1871, when the season's operations were brought to a close.

A line of piles 100 feet in length was also driven from the inner end of the west pier, along the line of revetment, shown on the original plan of improvement, to prevent the threatened cutting out of the river-waters back of the pier. These operations have thus fulfilled what was expected, as set forth in the last annual report.

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The *locale* has been found very favorable to this class of construction, the piles driving readily and deeply, and the work done of most excellent character.

The construction of these two piers induced marked changes. When the season of 1871 closed, the shore-line on the back or west side of the west pier had gained outward some 200 feet, indicating a great accretion from this direction. A tongue of sand just in the mouth, between the piers, formed, and kept working its way over to the west, from its side, the east, until it left at the inner end of the west pier a water-way of but 40 feet in width, cutting out to a depth of from 9 feet to 11 feet. This same accretion, extending outside the mouth, swept round in a curve till it struck the east pier, some 125 feet from its inner end, which, at the time of starting the pier, was close to the shore-line.

To the back or east of the east pier there has also been a gain outwardly of the shore-line 130 feet, though the accretion is less marked here than on the corresponding side of west pier, where, from the direction of the river's waters to this pier, as located and started, there was a decided and constant tendency to seek a new outlet to the back of the pier, behind its inside end, a tendency overcome by the line of piles, inside, above adverted to. An examination the present spring disclosed the cutting off of the "tongue" between piers, where the water-way was narrowed, and the increase of width of this, with the depth of from 8 feet to 10 feet. It was expected that the freshet of the spring would have carried away all this accretion, but as they were unusually light, they failed to cut away but the point of the "tongue." A beneficial effect of the improvement is at once noted in the channel following a straight course, parallel to the pier, out into the lake, instead of tending southwestwardly in a tortuous course, as it did before the building of the west pier.

Owing to the appropriation having been nearly exhausted during the working season of 1871, no new work has been attempted this season, so far: it is proposed, however, to enter into contract immediately for the extension of both piers, building 200 feet on each the present working season.

Respectfully submitted.

JAS. W. CUYLER,
Captain Engineers, United States Army.

Colonel D. C. HOUSTON,
Corps of Engineers, United States Army.

The work of the present fiscal year will be the extension of the piers as far as the appropriation of $25,000 will admit. An additional appropriation of $50,000 for the next fiscal year is estimated.

The total number of arrivals and departures at the port of Two Rivers, Wisconsin, during the year was as follows:

Four hundred and seventy-four arrivals and departures of steamers and propellers; 141 arrivals and departures of sailing-vessels.

Value of cargoes shipped, $1,258,318.70; value of cargoes received, $927,000.

Amount available July 1, 1871	$24,968 70
Amount appropriated by act of June 10, 1872	25,000 00
Amount expended during fiscal year ending June 30, 1872	21,684 21
Amount available July 1, 1872	28,284 49
Amount required for fiscal year ending June 30, 1874	50,000 00

A 10.

IMPROVEMENT OF MANITOWOC HARBOR, WISCONSIN.

Assistant W. H. Hearding, in immediate charge of this improvement, reports as follows:

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1872.

SIR: I have the honor to submit a report upon the work which has been effected at the harbor of Manitowoc, Wisconsin, during the fiscal year ending June 30, 1872.

Under the contract of R. A. Conolly of date June 15, 1871, an extension of 96 feet has been made to each of the piers confining the river-channel, the outer crib of each pier being of dimensions 64 by 20 feet; the inner crib on either side being 32 by 20 feet, the upper surface of the crib-timbers being 1 foot above the water-level at the

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time of sinking; the total length of the crib-work being consequently 192 running feet. Superstructure has also been built over the eight cribs which were sunk and filled under a previous contract with David Smoke, and a part of the requisite stone ballast furnished.

The total length of pier-work which has been constructed by the United States Government at this harbor is 2,566 running feet. The eastern extremities of the piers now extend to the natural water-line of 13 feet mean lake-level; but as the water at the present date is about 16 inches lower than the mean level of the lake, any vessel drawing more than 11½ feet cannot enter the harbor. The work of the present season includes the building of superstructure over the cribs which were sunk last year, filling up the piers with stone at points where it has settled to a serious extent, and protecting the piers by driving guard-piles.

Dredging is being done at the expense of the city, so that the mid-channel depth shall not be less than 13 feet.

On the 21st day of March, 1872, a settlement was effected with the administrator to the estate of David Smoke, deceased, whereby the percentage retained in accordance with his contract was surrendered.

The following is a statement of the quantity of materials used and labor performed under the contract of R. A. Conolly, of June 15, 1871:

Timber.		Pine plank.	White-oak piles.	Iron drift-bolts.	Spikes.	Stone.	Framing.	Piles driv'n.	Total am't paid to date.
Pine.	Hemlock.								
Lin. ft.	*Lin. ft.*	*Ft. (B. M.)*	*Lin. ft.*	*Pounds.*	*Pounds.*	*Cords.*	*Lin. ft.*	*No.*	
4,842	5,834	1,476	250	21,452.65	45	455.48	19,029	10	$8,369 33

Besides which there was used of Government timber left from David Smoke's contract: Of pine, 892 linear feet; of hemlock, 7,442 linear feet. It is expected that the work at this harbor will be completed by November, 1872. No appropriation has been made for the fiscal year ending June 30, 1873.

Since the improvements have been made by the United States Government there has been a large increase made in the commerce of the place, and it is expected that a further impetus will be given to business through the lines of railroad which are in process of construction to and from this point.

A dry-dock has been completed, which is capable of receiving vessels of the largest capacity for repairs, &c.

The number of steamers and sailing-vessels which have been built, and also the number of arrivals and departures of vessels, are as follows:

Arrivals during the year.—Steamers, 543; sail-vessels, 565.

Departures during the year.—Steamers, 545; sail-vessels, 572.

Steamers built, 2; sailing-vessels built, 6.

The number of vessels repaired has been 42. At the present time there are upon the stocks, building, 1 propeller and 4 sailing-vessels.

The exports during the past year have been larger than in any previous year, the only articles showing a decline being lumber, shingles, and railroad-ties.

Manitowoc is situated in the collection-district of Milwaukee, which is the nearest port of entry. The nearest light-house is at the harbor, of the fifth order of lens.

I have the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING.

Major D. C. HOUSTON,
Corps of Engineers, United States Army.

OFFICE OF UNITED STATES ENGINEERS,
Milwaukee, July 15, 1872.

SIR: I have the honor to acknowledge the receipt of your favor of the 13th instant, requiring an estimate of the cost of extending the piers at Manitowoc Harbor to a depth of 18 feet of water, mean lake-level.

The distance from the present extremities of the piers to a mean depth of 18 feet water is 400 feet.

The piers now extend to the natural line of 13 feet of water, mean lake-level, but close to the ends of the piers the water has washed out the sand, so that there is a depth of 15 feet. This depth being the limit to which a pier of 20 feet in width is usually carried, the additional height of 5 feet of superstructure making the height equal to the width. I have made the estimate for 800 running feet of crib-work of

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24 feet in width. The mean height of the sixteen cribs would be 22½ feet, allowing 5 feet for superstructure.

Estimated cost of crib, 50 by 24 by 22½ feet, to be placed on a stone foundation.

For 100 linear feet of pine timber, 12 by 18 inches, at 40 cents		$40 00
For 6,021 linear feet of timber, at 23 cents		1,384 83
For 9,851 pounds of iron drift-bolts, at 5½ cents		542 24
For 6,121 linear feet of framing, at 12 cents		734 52
For 141$\frac{55}{100}$ cords of stone ballast, at $9		1,274 58
Cost of one crib		3,976 17
Foundation:		
For 25 cords of stone, at $9		225 00
Intervals and footwalk:		
For 10 cords of brush, at $3	$30 00	
For 5 cords of stone, at $9	45 00	
For 450 feet (board measure) plank, at $20	9 00	
For 9 pounds spikes, at 10 cents	90	
		84 90
Cost of one crib, foundation, and interval		4,286 07
Add 10 per cent. for contingent expenses		428 60
Total cost of one crib		4,714 67
Total cost of sixteen cribs, ($4,714.67x16)		75,434 72

Respectfully submitted.

Your obedient servant,

W. H. HEARDING.

Brevet Colonel D. C. HOUSTON,
Major of Engineers, United States Army.

No appropriation was made for this harbor at the last session of Congress, and none was asked for, as the amount of the original estimate had been reached.

This estimate was based upon the plan adopted by my predecessor, Major J. B. Wheeler, Corps of Engineers, who uses the following language in his report of 1867:

It is well to state that the word "completion" is relative, meaning, in this case, the completion of the present plan. From the very nature of things, and this kind of work, a permanent completion cannot be expected.

I therefore submit herewith an estimate of $80,000 for the further extension of the piers, and an estimate of $40,000 for the next fiscal year.

Amount available July 1, 1871	$20,459 04
Amount expended during the fiscal year ending June 30, 1872, including $336.92 retained from payments to contractors	9,880 08
Amount available July 1, 1872	10,578 96
Amount required for fiscal year ending June 30, 1874	40,000 00

A 11.

IMPROVEMENT OF SHEBOYGAN HARBOR, WISCONSIN.

The operations of the year are reported as follows by the assistant in charge, Mr. W. H. Hearding:

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1872.

SIR: The following report upon the harbor of Sheboygan, Wisconsin, is respectfully submitted.

Since the date of the last annual report, of June 30, 1871, and under the contract made with F. M. Knapp, of Racine, Wisconsin, of date September 3, 1870, 192 running feet of crib-work 20 feet in width were built to the water-surface, in extension of the north pier; also, under his contract with the Government of date June 17, 1871, 256 running feet of crib-work have been built, of the same width, 128 feet of which were

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placed in extension of the north pier, and the same length was in extension of the south pier, forming a total length of pier-extension under both contracts of 448 running feet, built in 7 separate cribs, each of dimensions 64 feet in length by 20 feet in width.

The quantities of materials used and amount of labor performed, with the amount of expenditure, are shown in the following table:

Pine timber.	White-oak piles.	Pine plank.	Stone.	Iron drift-bolts.	Screw-bolts.	Spikes.	Framing.	Piles driven.	Amount paid.
Lin. ft.	*Lin. ft.*	*Ft. (B. M.)*	*Cords.*	*Pounds.*	*Pounds.*	*Pounds.*	*Lin. ft.*	*No.*	
37, 160½	875	7, 024	1, 107. 75	49, 402. 44	498. 66	177¼	38, 325	27	$23, 210 46

The character of the lake-bed at this point is unfavorable to the settling of crib-structures, being formed of a loose, shifting sand, and the cribs which were sunk without being previously provided with stone foundations upon which they could rest have tilted seriously. The work of building superstructure over these cribs is in active progress, and, it is expected, will be completed during the month of July.

It is proposed to finish the piers by placing a crib of dimensions 50 by 30 feet at the extremity of each. Bids will be received for the construction of these cribs on the 5th day of August, 1872. It is also proposed to dredge about 5,000 cubic yards of sand out of the channel, and make repairs to the piers where most needed. This work will be done by contract, under appropriation for the improvement of this harbor by act of Congress dated June 10, 1872.

The number of arrivals and departures of steamers and sailing-vessels during the past year is as follows:

	Arrivals.	Departures.
Of steamers	522	523
Of sail-vessels	321	316
Total	843	839

This number does not include vessels which have taken shelter in the harbor from stress of weather.

An approximate account of imports and exports is as follows:

Imports.—Merchandise, 79,242 packages; iron, 441,200 pounds; railroad-iron, 2,000 tons; nails, 2,140 kegs; coal, 1,600 tons; salt, 7,821 barrels; corn, 2,820 bushels; lumber, 3,720,000 feet, board measure; shingles, 640,000; plaster, 2,100 tons; bark, 1,341 cords; sundries, 8,972 packages.

Exports.—Wheat, 572,000 bushels; flour, 32,720 barrels; 26,590 packing-barrels; wool, 76,520 pounds; horned cattle, 321; peas, 42,321 bushels; chairs, 16,000; sundries, 61,320 packages.

During the past year the Sheboygan and Fond du Lac Railroad has been extended westward as far as Princeton, a distance of seventy-nine miles, and a daily line of propellers established from this port to Pentwater, Michigan. It is expected that the facilities for doing business opened by these routes will increase the commerce of the place materially during the next year.

Sheboygan is situated in the collection-district of Milwaukee, which place is also the nearest port of entry. The nearest light-house is about one mile north of the harbor, and shows a fixed white light, furnished with a fifth order of lens.

I have the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING.

Brevet Colonel D. C. HOUSTON,
Major of Engineers, United States Army.

The sum appropriated at the last session of Congress ($18,000) does not cover the work of repairs required at this harbor, as estimated in my annual report for 1871, when I estimated the sum of $28,000.

An estimate of $10,000 is, therefore, submitted for the year ending June 30, 1874.

Amount available July 1, 1871	$29, 086 70
Amount appropriated by act of June 10, 1872	18, 000 00
Amount expended during the fiscal year ending June 30, 1872, including $938.48 retained from payments to contractors	23, 856 95
Amount available July 1, 1872	23, 229 75
Amount required for fiscal year ending June 30, 1874	10, 000 00

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A 12.

IMPROVEMENT OF PORT WASHINGTON HARBOR, WISCONSIN.

The assistant in immediate charge, Mr. W. H. Hearding, reports the operations of the year as follows:

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1872.

SIR: I have the honor to report upon the work of improvement which has been effected at the harbor of Port Washington during the past fiscal year.

Under the agreement made with Mr. Albert Conro, of Milwaukee, of date June 12, 1871, ten cribs, each 64 feet in length, 14 feet in width, and 14½ feet in height, were built and sunk in a depth of 9½ feet of water, five of which were placed on the north and five on the south side of the channel leading to the proposed basin. The direction of the piers is approximately S. E. by E.½ E. They are built parallel with each other, the width of channel between them being 150 feet.

The cribs are well constructed, and were set, and remain in excellent alignment. The necessary dredging for setting these cribs was done at the expense of the town of Port Washington, as was also the dredging which was done in the channel. The material composing the bed of the channel is a stiff clay, mixed with bowlders. By reason of this favorable character of material for crib-foundations, (there being no probability of the crib settling,) the superstructure was finished over the whole of the cribs by the time specified in the agreement, viz, December 1, 1871, the whole of the work having been done satisfactorily. The cost of building and sinking these ten cribs, and covering them with superstructure, was originally estimated at $18,774.30. The quantity of materials used and labor performed in their construction was as follows, viz:

Of timber used, 34,190 linear feet, at 18 cents	$6,154 20
Of stone ballast, 723.25 cords, at $6.50	4,701 12
Of brush filling, 50 cords, at $3	150 00
Of iron drift-bolts, 52,840.69 pounds, at 4½ cents	2,245 72
Of iron spikes, 200 pounds, at 7 cents	14 00
Of framing-timber, 34,190 linear feet, at 12 cents	4,102 80
Total cost	17,367 84

The work proposed to be done during the fiscal year ending June 30, 1873, is the extension of each of the piers 100 feet; each extension to be formed of two cribs of dimensions 50 by 20 feet; also the dredging of about 6,000 cubic yards in the basin, and for setting the cribs.

The improvement of this place by the construction of a basin promises to be a complete success. Already a large and increasing business is transacted from the basin.

Since opening of navigation in April of this year, sixty-eight vessels, with a carrying-capacity of 204,000 bushels, have entered and cleared from the basin; all of which departed with full cargoes of grain, cord-wood, brick, stone, hay, provisions, &c., and almost all of which brought to the place full cargoes of merchandise.

Besides these, three vessels ran into the harbor for shelter during storms. Vessels drawing 6½ feet of water can run into the basin by keeping close to the north pier.

The quantity of merchandise which has passed over the bridge-pier, which is owned by private parties, during the past year, is as follows, viz: Of wheat, 112,285 bushels; oats, 26,360 bushels; barley, 750 bushels; malt, 30,000 pounds; flour, 2,000 barrels; butter, 427,500 pounds; eggs, 2,065 barrels; shooks, 13,000 bundles; wood, 1,550 cords; pork, 150 barrels; wool, 3,500 pounds; hay, 210 tons; potatoes, 12,450 bushels; wagon-hubs, 1,600 sets; plows, 300; hams and shoulders, 16,050 pounds; peas and beans, 3,685 bushels; tallow, 6,400 pounds; hides, 15,600 pounds.

Port Washington is situated in the collection-district of Milwaukee, which is the nearest port of entry.

The nearest light-house is at the harbor.

Respectfully submitted.

Your obedient servant,

W. H. HEARDING.

Brevet Colonel D. C. HOUSTON,
Major of Engineers, United States Army.

The total appropriations for this work, including that of June 10, 1872, of $15,000, amount to $45,000.

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An estimate of $50,000 is submitted for the next fiscal year to be applied to extending the piers, and excavating the channel and basin.

Amount available July 1, 1871	$20,542 70
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during fiscal year ending June 30, 1872	18,978 69
Amount available July 1, 1872	16,564 01
Amount required for fiscal year ending June 30, 1874	50,000 00

A 13.

IMPROVEMENT OF MILWAUKEE HARBOR, WISCONSIN.

The operations of the year are given in the following report of Assistant W. H. Hearding, in immediate charge of the improvement.

OFFICE OF UNITED STATES ENGINEERS,
Milwaukee, June 30, 1872.

SIR: The following report upon the work which has been done at the harbor of Milwaukee, Wisconsin, during the past fiscal year, is respectfully submitted.

Under the contract of Messrs. Hasbrouck & Conro, of this city, dated September 21, 1870, eight cribs, of dimensions 50 by 26 feet, were sunk and filled with stone ballast, the cribs being built to height of 1 foot above mean lake-level, four of which, equal to an extension of 200 feet, were placed on the north side, and the remaining four were placed on the south side of the harbor-channel. This work was effected by the contractors before the 1st of December, 1871, according to the terms of agreement, and closing the contract.

The quantity of materials used and labor paid for in the construction of these eight cribs was as follows, viz:

45,733 linear feet of pine timber, at 16¼ cents	$7,545 94
1,341.75 cords of stone ballast, at $8.25	11,069 43
65,862.19 pounds of iron drift-bolts, at 3¾ cents	2,469 83
75 pounds of iron screw-bolts, at 6¼ cents	4 87
45,733 linear feet of framing, at 8¼ cents	3,772 97
Total cost of eight cribs to 1 foot above water-surface	24,863 04

On the 17th day of June, 1871, a contract was entered into by Henry Starke, of the city of Milwaukee, to construct a further extension of 150 running feet to each of the piers, to consist of two cribs, each 50 by 26 feet, and one crib, of dimensions 50 feet in length by 30 feet in width, on each side of the channel, and to build superstructure over the whole fourteen cribs embodied in the two contracts. These last six cribs specified in Starke's contract were built to a height of 1 foot above mean lake-level: the last of them being sunk in position and filled with ballast on the 25th day of November, 1871.

The quantity of materials used and labor paid for in the building and sinking of the six cribs was as follows, viz:

Materials used.									Labor paid for—		Amount paid.
Timber.			Pine plank.	Oak piles.	Iron.			Stone.	Framing.	Piles driven.	
Pine.	Hemlock.	Oak.			Drift-bolts.	Screw-bolts.	Spikes.				
Lin. ft.	*Lin. ft.*	*Lin. ft.*	*Ft. (B. M.)*	*Lin. ft.*	*Lbs.*	*Lbs.*	*Lbs.*	*Cords.*	*Lin. ft.*	*No.*	
33,371	1,066	108	6,000	480	46,897.16	3,653.80	391	1,075.6	36,045	16	$21,440 77

Mr. Starke commenced building the superstructure over the seven cribs forming the north pier-extension early in May of this year. He has nearly completed the same to a mean height of 5½ feet above mean lake-level; the outer crib, 50 feet by 30 inches,

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being 7½ feet above that datum. The whole of the work, as far as completed, is well done and ballasted with stone. The quantity of materials used and labor performed in building this superstructure to date is as follows:

10,310 linear feet of pine timber at 19.3 cents	$1,989 83
46½ linear feet of oak timber, at 30 cents	13 95
234 linear feet of oak piles, at 16 cents	37 44
12,746 pounds of iron drift-bolts, at 4½ cents	525 80
49 pounds of iron spikes, at 7 cents	3 43
171 pounds of iron screw-bolts, at 10 cents	17 10
504.9 cords of stone ballast, at $8	4,039 20
10,356½ linear feet of framing, at 10 cents	1,035 65
Driving 9 piles, at $5	45 00
Total	7,707 40

The third crib from the outer end of the north pier was struck by some unknown vessel and damaged to a serious extent, soon after the crib was placed in position. The fracture was repaired and the superstructure carried by means of piles.

It is expected that two cribs of the south pier, which have been damaged by collision, will be repaired, and the whole of the superstructure built over the seven cribs forming the south pier-extension, during the present working season; also, that protection will be given to the ends of the piers by driving clumps of piles, five to each clump, to be sprung together and banded with chains; also, that repairs will be made to a portion of the inner (or old) cribs.

As the stage of water in the lakes is low during the present season, one or two vessels which have been deeply laden have experienced some little difficulty upon entering, but by keeping in the deepest part of the channel, vessels drawing 14 feet of water can effect a ready entrance by changing their course but once for the entire length of the cut. To make a uniform depth of water of 14 feet, along the whole length of the cut at the present stage of water, which is 1 foot 4 inches below mean lake-level, and a width of 220 feet, the amount of dredging necessary to effect the same would be about 14,000 cubic yards.

The number of arrivals of steamers and sailing-vessels during the past fiscal year has been 7,042, with a tonnage-capacity of 2,607,850 tons. Of departures, 7,042 with tonnage-capacity of 2,611,384 tons.

Amount of duties collected during the fiscal year, $134,264.73 in gold.

Receipts from tonnage-duties, inspection of steamers, licenses, enrollments, and marine hospitals, $13,714.30.

The nearest light-house is situated at the north point of Milwaukee Bay, which is three miles distant from the harbor-channel, being provided with a fourth order of lens. Its height above the level of the lake is 102 feet. There is also a beacon-light on the north pier, at a distance of 680 feet from the extreme end.

I have the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING.

Major D. C. HOUSTON,
Corps of Engineers, United States Army.

No appropriation was made for this harbor at the last session of Congress, nor was any asked for, as the amount of the original estimate had been reached, and it was estimated that the funds available would extend the piers out as far as was necessary. The piers have already been extended out to a depth of 17 feet at the ordinary stage of water, and the funds on hand will complete the superstructure and repair the old work as far as it is deemed necessary at present. No further extension of the piers will be required for some time to come.

In order to put this harbor in good condition the channel between the piers should be excavated to a depth of 14 feet at all stages of water, and I estimate that the sum of $10,000 will suffice to do this thoroughly. If it be the intention of the Government to do all that is necessary to complete and maintain this harbor, without reference to local aid, this sum will be required.

Amount available July 1, 1871	$75,121 79
Amount expended during the fiscal year ending June 30, 1872, including $2,470.94 retained from payments to contractors	53,291 03
Amount available July 1, 1872	21,830 76
Amount required for fiscal year ending June 30, 1874	10,000 00

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A 14.

IMPROVEMENT OF RACINE HARBOR, WISCONSIN.

The operations of this harbor are reported as follows by Assistant W. H. Hearding, who has had immediate charge:

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1872.

SIR: I have the honor to submit the following report upon the harbor of Racine, Wisconsin.

On the 30th day of September, 1870, a contract was made by the United States Government with Mr. F. M. Knapp, of Racine, under which he was to construct 256 running feet of crib-pier work to the water-surface, of 20 feet in width, in extension of the south pier.

As the working season was far advanced at the time of effecting the contract, work was not commenced upon the piers until May, 1871. At the date of the annual report, June 30, 1871, the contractor had built 128 running feet of crib-work to the water-surface. The remaining 128 feet were built and finished to a height of 1 foot above mean lake-level in July, 1871. Repairs were made to a portion of the old work, at the west end of the north pier, for a length of 206 running feet, by taking out the old timber, and replacing it with new. This new superstructure was built 12 feet in width, and filled with slabs covered with stone ballast.

The cribs built in extension of the south pier settled very unevenly, tilting out of their proper alignment. The quantity of materials used and labor performed in the construction of the south pier-extension to water-surface, and making repairs to north pier, were as follows: Of pine timber 24,246½ linear feet; pine plank, 78 feet, board measure; iron drift-bolts, 30,623 pounds; iron screw-bolts, 50 pounds; iron spikes, 100 pounds; oak piles, 144 linear feet; stone ballast, 655.54 cords; slabs, 70.12 cords; framing, 24,262½ linear feet; old timber taken out and replaced, 1,111 linear feet; piles driven, (number) 8.

The contractor has been engaged during the past month in building superstructure over the south pier-extension, and it is expected that he will have completed the same before the 1st day of August.

At this, as at other harbors on the west shore of Lake Michigan which are southward of Milwaukee, it would seem to be essential to carry out the north pier to such a distance beyond the extremity of the south pier as to protect it from seas produced by northeast storms.

The general impression at this particular point is that the extension which has been made to the south pier has been prejudicial to the maintenance of as deep a channel between the piers as would have been maintained provided an extension of equal length had been given to the north pier, and from personal observation I am inclined to the belief that the north pier at this harbor should be extended 150 feet further into the lake than it is at the present time. It now projects 75 feet beyond the extremity of the south pier. To effect this would require the building of three cribs, each of dimensions 50 by 30 by 26½ feet, placed upon foundations of stone. An estimate of the cost of building and completing these three cribs, protecting the end of pier, and filling intervals between cribs, is respectfully submitted as follows, viz:

Estimate of cost of one crib 50 by 30 by 26½ feet.

8,099 linear feet of timber, at 23 cents		$1,862 77
12,061 pounds of iron drift-bolts, at 5½ cents		663 35
216.30 cords of stone ballast, at $10.50		2,271 15
8,099 linear feet of framing, at 12 cents		971 88
Cost of crib		5,769 15
Foundation:		
30 cords of stone, at $10.50		315 00
Interval and footwalk:		
16 cords of brush, at $4	$64 00	
7 cords of stone, at $10.50	73 50	
450 feet (board-measure) plank, at $18	8 10	
9 pounds of spikes, at 8 cents	72	
Cost of interval and footwalk		146 32
		6,230 47

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Add 10 per cent. for contingencies	$623 04
Total cost of one crib, interval, and footwalk	6,853 51
Total cost of three cribs, interval and footwalk, ($6,853.51×3)	20,560 53
Cost of protection to outer crib	473 75
Total	21,034 28

The number of arrivals and departures of steamers and sailing-vessels during the past year is as follows:

	Arrivals.	Departures.
Steamers	496	494
Sail-vessels	559	555
Total	1,055	1,049

The principal imports have been: Of lumber, 23,003,198 feet, board-measure; lath, 2,548,000; shingles, 10,459,000; coal, 16,304 tons; bark, 2,417 cords; cedar posts (number,) 27,270; salt, 2,000 barrels; railroad-ties, (number,) 56,947; wood, 5,076 cords; packages of merchandise, 13,954.

Exports.—Corn, 154,405 bushels; flour, 786 barrels; oats, 11,965 bushels; hay, 1,760 tons.

The value of agricultural implements, and other articles of manufacture which have been exported during the past year, is estimated at two and three-fourth millions of dollars, seven-eighths of which were shipped to the interior by rail.

The domestic and foreign imports and exports have fallen from seven and one-half million dollars in 1868, to $2,380,000 in 1872. This falling off is attributed to the sale of the Western Union Railroad to the Milwaukee and Saint Paul Company.

Racine is situated in the collection-district of Milwaukee, which is the nearest port of entry. The nearest light-house is at the pier on the north side of the harbor-channel, displaying a fixed white light, provided with a lens of the fifth order, and is 47½ feet above lake-level.

I have the honor to remain, your obedient servant,

W. H. HEARDING.

Brevet Colonel D. C. HOUSTON,
Major of Engineers, United States Army.

The views of Assistant Hearding are concurred in as to the necessity of extending the north pier. The original plan contemplated that both piers should be extended out equally. Later investigations have shown that in this portion of the lake the north pier should be longer than the south.

The direction of the piers being east and west, and the prevailing storms being northeast, the south pier, when extended out as far as the north pier, catches the material driven in by storms, and causes it to be deposited in the harbor. To prevent this the south pier should never be extended in such cases beyond a northeast and southwest line passing through the end of the north pier. For these reasons the sum of $20,000 is estimated for this improvement.

Amount available July 1, 1872	$17,285 65
Amount expended during the fiscal year ending June 30, 1872, including $546.25 retained from payments to contractors	13,120 88
Amount available July 1, 1872	4,164 77
Amount required for fiscal year ending June 30, 1874	20,000 00

A 15.

IMPROVEMENT OF KENOSHA HARBOR, WISCONSIN.

Assistant W. H. Hearding, assistant in charge, reports as follows:

OFFICE UNITED STATES ENGINEERS,
Milwaukee, June 30, 1872.

SIR: The following report upon the harbor of Kenosha, Wisconsin, for the fiscal year ending the 30th of June, 1872, is respectfully submitted.

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On the 15th of June, 1871, a contract was entered into by R. A. Conolly, of Chicago, Illinois, with the Government, under which he was to drive piles in juxtaposition around the displaced, broken crib, build superstructure over the same, and fill the interior space with stone ballast; also, to build and place a crib, 50 feet in length by 30 feet in width, upon an alignment with the south face of the north pier, outside, or to the eastward of the piling around the displaced crib, and connected with it by a continuous superstructure.

With the exception of making repairs to the south pier, the work has been accomplished. It will be necessary, however, to place more ballast in the superstructure, as the piers at this point are exposed to very heavy seas from northeast storms.

About 25 cords of stone have been put into the older portion of the work, on the north pier, outside, or to the eastward of the pier-beacon. This was necessary to insure its safety. The materials used and labor performed in the accomplishment of this work, with the cost of the same, are stated in the following table:

Timber.			Iron.			Pine plank.	Oak piles.	Stone.	Framing.	Piles driven.	Repairs.	Amount paid.
Pine.	Hemlock.	Oak.	Drift-bolts.	Screw-bolts.	Spikes.							
Lin. ft.	*Lin. ft.*	*Lin. ft.*	*Lbs.*	*Lbs.*	*Lbs.*	*Ft. (B. M.)*	*Lin. ft.*	*Cords.*	*Lin. ft.*	*No.*	*Lin. ft.*	
7,095	1,559	141½	11,253	919	108	5,074	2,575	376.3	9,127½	78	330	$8,321 88

During the fiscal year ending June 30, 1873, it is proposed to extend the north pier by the construction and sinking of a crib, 50 feet in length by 30 feet in width, making repairs to the south pier, and protect the extremities of the piers by driving piles, in clumps of five to each clump, and banding the same with chains. As there is but little or no current from the river emptying into the harbor-basin, or from the extensive bayou trending along the shore, inside the point of land from the northward, there is no scouring force applied to free the channel from sedimentary deposits, except such as is produced by tidal influences, due to changes in the direction of the wind. The length of the channel between the piers is about 1,200 feet; its width, 150 feet; the average depth is about 9½ feet mean lake-level. It is important to the commercial interests of the place that the channel be deepened. To give a channel of 14 feet in depth, at mean lake-level, for the length of the piers, would require the removal of 30,000 cubic yards of material by dredging, estimated in place; or, by scow-measurement, about 40,000 cubic yards. This could probably be done at a cost of 28 cents per cubic yard, or $11,200. The citizens of the place are very desirous that this be done. The number of arrivals of sailing-vessels at this harbor during the fiscal year was 259; of departures during the fiscal year was 257. Two or three light-draught propellers also came in within the same period, but not carrying a coasting license did not report at the custom-house. The commerce of the place is said to be improving.

Kenosha is situated in the collection-district of Milwaukee, which place is also the nearest port of entry. The nearest light-house is situated near the harbor-channel, on the north side. The light is fixed, varied by flashes at intervals of one and one-half minutes. Its height is 76 feet above the level of Lake Michigan.

I have the honor to remain, very respectfully, your obedient servant,

W. H. HEARDING.

Brevet Colonel D. C. HOUSTON,
Major of Engineers, United States Army.

For the reasons stated in the report on Racine Harbor the available funds will be applied to the extension of the north pier 50 feet, and to repairs of the south pier. The sum of $15,000 is estimated for the year ending June 30, 1874, to be applied to dredging a channel between the piers.

Amount available July 1, 1871	$13,307 79
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during the fiscal year ending June 30, 1872, including $447.28 retained from payments to contractors	5,408 79
Amount available July 1, 1872	17,899 00
Amount required for fiscal year ending June 30, 1874	15,000 00

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A 16.

IMPROVEMENT OF CHICAGO HARBOR, ILLINOIS.

The operations during the year have consisted in the extension of the breakwater to the south, a distance of 800 feet, and the construction of a return at the north end, 300 feet in length. There were constructed at the close of the year ending June 30, 1872, 2,250 feet of breakwater, including superstructure very nearly finished, at a total cost of $200,000, or $88.88 per running foot. This also includes the protection of the north end of the work by clumps of piles. The whole work may be safely estimated at $100 per foot, including covering and contingencies. It is proposed with the present appropriation of $90,000 to continue the extension of the breakwater, and, if necessary for protection of the harbor, to add 100 feet to the return at the north end of the breakwater, as originally designed.

It is estimated that 800 feet will be added to the breakwater during the present fiscal year, making a total length of 3,050 feet, and leaving 950 feet to complete the breakwater according to the original plan. In addition to this, the plan adopted contemplated the construction of a pier connecting the south end of the breakwater with the shore, at an estimated cost of $167,418.38.

Adopting this estimate, a further appropriation of $267,000 will be required to complete the work according to the plan adopted, or a total sum of $557,000, which, owing to the price of materials and labor, is much less than the original estimate. It has occurred to me that the interest of this harbor would be better subserved if, instead of constructing the south pier as proposed, the funds should be applied in extending the breakwater.

If the breakwater were prolonged in its present direction it would afford all the protection required to the harbor now being formed, and if the lake-front is made use of for the construction of wharves and slips, as contemplated in the construction of this harbor, the necessities of the case will require this extension south of the limits of the harbor now proposed, and consequently protection. In this case the south pier would interfere with the navigation of vessels in the lake-front. If the lake front is used at all for such purposes it will not stop at the present limit of the proposed harbor, but will extend indefinitely as the requirements of commerce demand. The sum of $200,000 can be advantageously expended during the fiscal year ending June 30, 1874.

The following letter of Hon. N. B. Judd, collector of the port, is respectfully transmitted, giving the arrivals and departures of vessels, and amount of revenue collected:

CUSTOM-HOUSE, CHICAGO, ILLINOIS.
Collector's Office, July 24, 1872.

SIR: In reply to your request of 22d instant I have to inform you that the numbe and tonnage of vessels that arrived and departed at this port during the year ending June 30, 1872, are as follows:

Vessels entered.—Number, 11,612; tonnage, 2,823,279.

Vessels cleared.—Number, 11,157; tonnage, 2,760,923.

The total amount of revenue collected during the ten months ending June 30, 1872, is $1,265,031.63.

Owing to the loss of the records of this office by the fire of October 9, 1871, I can only refer you to Bureau of Statistics, Washington, D. C., for amount collected during the months of July and August, 1871.

I am, very respectfully,

N. B. JUDD, *Collector.*

Major D. C. HOUSTON,
Engineer Corps, United States Army, City.

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Amount available July 1, 1871	$120,405 23
Amount appropriated by act of June 10, 1872	90,000 00
Amount expended during the fiscal year ending June 30, 1872, including $8,617.02 retained from payments to contractors	112,244 12
Amount available July 1, 1872	98,161 11
Amount required for fiscal year ending June 30, 1874	200,000 00

A 17.

IMPROVEMENT OF CALUMET HARBOR, ILLINOIS.

The work at this harbor has consisted in the construction of the south pier and the extension of the north pier, making, in all, 1,700 feet of pier and revetment.

The channel between the piers has also been deepened and widened. The operations proposed for the present fiscal year, to which the appropriation of $40,000 by the act of June 10, 1872, will be applied, will consist in extending the north pier about 700 feet out, to a depth of 14 feet of water, and continuing the excavation of the channel.

It is estimated that with this pier-extension, a permanent though narrow channel of 11 or 12 feet can be secured.

The sum of $140,000 has thus far been appropriated. The original estimate for this harbor was, in round numbers, $300,000.

The sum of $75,000 can be profitably expended in continuing the improvement during the fiscal year ending June 30, 1874. This sum will put the harbor in a condition to fulfill the object for which it was designed, viz, a harbor of refuge for vessels failing to make Chicago Harbor during northerly storms.

The total number of vessels arriving and departing from Calumet Harbor during the year was 143.

Amount available July 1, 1871	$65,903 07
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during the fiscal year ending June 30, 1872	59,637 97
Amount available July 1, 1872	46,265 10
Amount required for the fiscal year ending June 30, 1874	75,000 00

A 18.

IMPROVEMENT OF MICHIGAN CITY HARBOR, INDIANA.

The operations at this harbor have consisted in dredging between the piers, and in repairing and covering the piers. Seventy thousand cubic yards of material have been dredged and dumped in the lake.

The old piers have been repaired by private parties using them as docks, so that the sides of the channel are pretty well protected. The mouth of this harbor will require to be dredged out annually until the outer harbor, which will be commenced under the appropriation of $50,000 by the act of June 10, 1872, is completed, or nearly so. It is expected to commence work on this outer harbor the present season.

The original estimate for this harbor by a board of engineers was $324,000. This amount will be considerably reduced if the plan of a pile-breakwater, which has now been adopted, is found to be successful. The sum of $100,000 can be advantageously expended during the season of 1873.

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The total number of vessels arriving and departing from Michigan City Harbor during the year was 322.

Total lumber received, 33,000,000 feet, board-measure; total pig-iron received, 6,500 tons; total salt received, 3,000 barrels; aggregate value of receipts, $700,000; total lumber shipped, (black walnut,) 715,000 feet, board-measure.

Amount available July 1, 1871	$26,916 26
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during the fiscal year ending June 30, 1872	17,166 81
Amount available July 1, 1872	59,749 55
Amount required for fiscal year ending June 30, 1874	100,000 00

A 19.

IMPROVEMENT OF NEW BUFFALO HARBOR, MICHIGAN

During the past year the east pile-pier, commenced in the spring of 1871, has been completed for a distance of 301 feet from the shore, with the exception of the filling, which the contractor failed to put in.

The small amounts appropriated for this harbor are insufficient to produce any decided benefit. The original estimate for this harbor was $384,020.

The board of engineers convened for the consideration of this harbor on June 24, 1868, increased this estimate to $500,000. There was appropriated, in 1867, the sum of $60,000. This was expended in interior work, cutting a channel from Lake Pottawatomie to the lake, and protecting this with a revetment of sheet-piling.

The mouth of this channel being unprotected by piers, the lake at once filled up by the action of storms, so that the work accomplished, though necessary as a part of the plan, did not contribute to the immediate availability of the harbor.

It would have been more expedient, in my judgment, to have expended this sum in the construction of parallel piers in the lake out to a depth of 9 or 10 feet of water, before attempting to dredge a channel, which would then have been protected from filling by the piers.

In 1870 an appropriation of $5,000 was made for this harbor, which made, with the balance of the old appropriation, the sum of about $11,000. In accordance with the above-expressed views this sum has been applied to the construction of a pier extending into the lake on the east side of the proposed channel, but is not yet extended out sufficiently to afford much protection. This year an appropriation was made of $5,000, which, with the balance in hand, will be applied to the construction of the west pier, about 300 feet in length. The funds appropriated are not sufficient to put the work in a condition to afford any benefit to navigation, and it will require fifty years to complete the work according to the original estimate if but $5,000 is appropriated annually.

In order to accomplish anything at this harbor it is necessary to have sufficient funds to carry out the piers to a depth of 10 feet, and dredge a channel for light-draught vessels between them. This will require an appropriation of $75,000. If it be determined to make a harbor at this point, I would recommend the appropriation of this sum at once. The local necessities, which are very small, will then be met, and additional appropriations can be applied to advantage. The present appropria-

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tions are so small that it is impossible to make a contract to advantage. The same investment for machinery and tools is required as for larger work, and there is not margin for a reasonable profit by the contractor.

There is no difficulty in making a good harbor at this point. It is not as favorable a locality as others, so far as the difficulties of construction are concerned, but the making of a good harbor is entirely practicable. It is only a question of expense.

Amount available July 1, 1871	$8,238 56
Amount appropriated by act of June 10, 1872	5,000 00
Amount expended during the fiscal year ending June 30, 1872, including $552.21 retained from payments to contractors	4,414 32
Amount available July 1, 1872	8,824 24
Amount required for fiscal year ending June 30, 1874	75,000 00



A 20.

IMPROVEMENT OF WISCONSIN RIVER, WISCONSIN.

Operations for the improvement of this river were commenced about July 1, 1871, and the results of last season's operations are found reported in Ex. Doc. No. 176, Forty-second Congress, second session, House of Representatives. The results of these operations were such as to lead to the belief that the natural channel of the river was susceptible of improvement by confining the waters of the river at the low-water stage by means of wing-dams to a single channel, and reducing its width as far as necessary. The work this season has been directed to this object, and the operations are reported by the assistant in charge, Mr. John Nader, as follows:

The actual work of improving the river commenced with the fiscal year, although a small sum was expended in June in preparing materials.

The first operations partook of an experimental nature to determine the feasibility of several projects based upon the examinations and surveys of General G. K. Warren. one of which was that of an independent canal, and, although the most expensive, was considered the most reliable, provided the experiments would determine the possibility of maintaining several crossings, which it would be necessary to make to avoid some of the larger tributaries and to work upon advantageous ground.

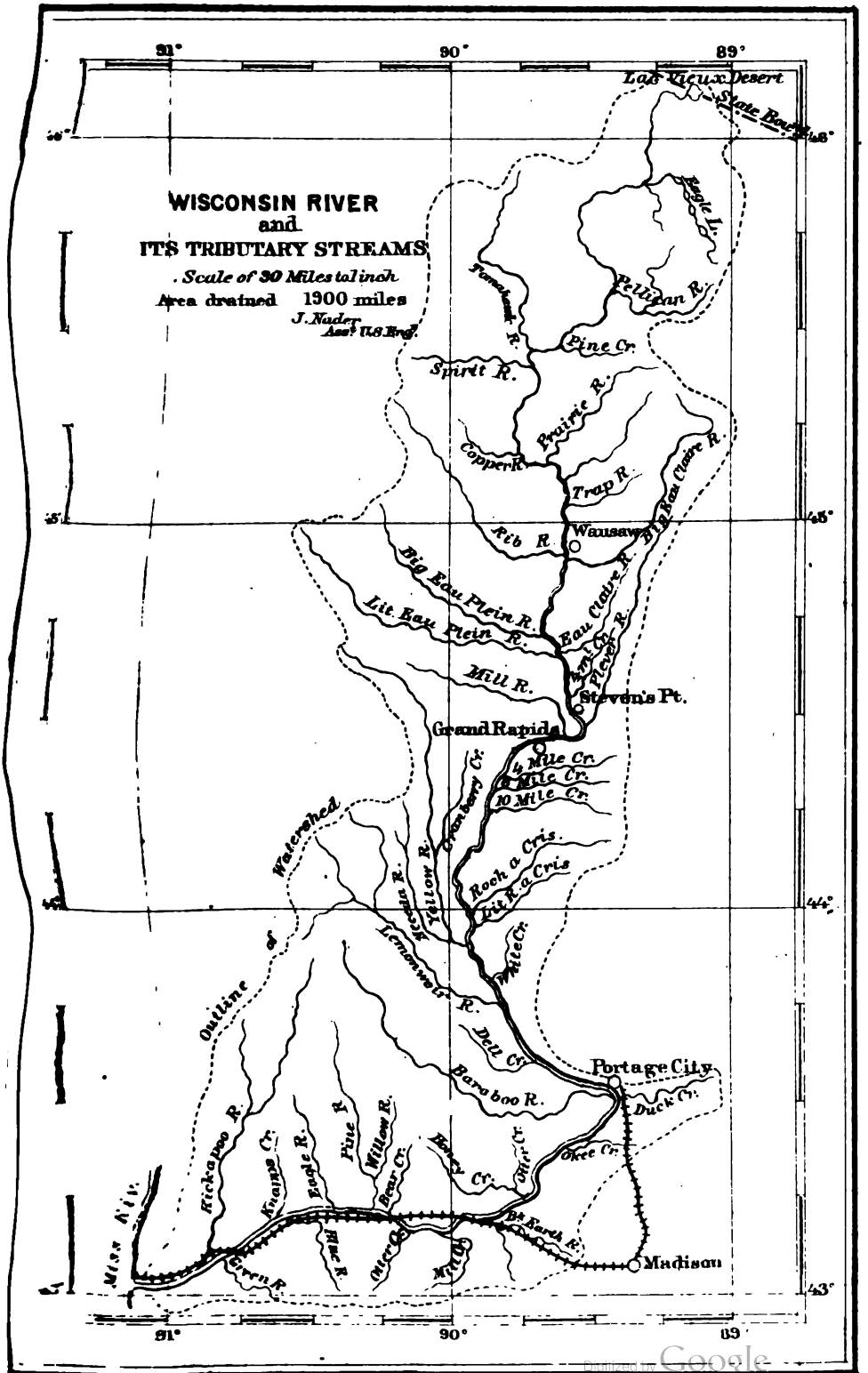
The other projects were the improvement of the river-bed itself for several depths of channel, but not considered reliable in the absence of data, partaking of this special nature, on the uncertainty of the stability of any work based upon the shifting sands of the river-bed.

The general features of the river have already been fully discussed in my report of December 26, 1871, on the experimental improvements, so far as it was possible with the information then at hand. Other information since obtained requires some special remarks.

The river is obstructed by sand-bars, which move at variable rates during moderate stages. The motion depends not so much upon the stage of water as upon the rapidity of the change from high to low; the bars appear to move more from pressure than by the current. Where the latter exists the flow soon makes a decided channel. A section was measured of 325 feet wide, with a maximum depth of 7.4 feet, and a mean depth of 6 feet, with a mean velocity of 1.95 miles per hour. This channel maintains its depth at all times. The general idea existed that at high water a general motion of sand took place, but upon observing, during the past spring rise, I could not detect anything of the kind. When the water had risen sufficient to create a current of between two and three miles per hour, the bars disappeared by flatting out, and remained so until the water had again fallen below that stage. Ten hours after the fall I observed the first appearance of the bars, only a little further on; the sand, in forming the bar, having moved sufficiently far to form the reef. The rising water also attacks the banks by its action against the vertical banks of the bottom lands and terraces. The action ceases after the same are overflowed, unless the current be strongly directed against the bank, under which conditions only a sloping bank will also be attacked.

The annexed sketch (Fig. 1) shows the general course of the river and its tributaries, draining an area of 11,900 square miles.

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WISCONSIN RIVER
and
ITS TRIBUTARY STREAMS
Scale of 30 Miles to inch
Area drained 1900 miles
J. Nader
Ass't U.S. Eng.
91°
90°
89°
48°
45°
44°
43°
Lac Vieux Desert
State Boundary
Eagle R.
Pelican R.
Pine Cr.
Spirit R.
Prairie R.
Copper R.
Trap R.
Rib R.
Wausau
Big Eau Claire R.
Eau Claire R.
Big Eau Plein R.
Lit Eau Plein R.
Mill R.
Steven's Pt.
Grand Rapids
Cranberry Cr.
Yellow R.
Watershed
Roche a Cris
Lemonweir R.
Mile Cr.
Dell Cr.
Portage City
Baraboo R.
Duck Cr.
Outline of
Kickapoo R.
Knapp Cr.
Eagle R.
Pine R.
Willow R.
Bear Cr.
Honey Cr.
Otter Cr.
Oree Cr.
Miss. R.
Black R.
Mirror L.
Madison
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Next to the obstructions rendered by sand-bars, are the railroad-bridges. The bridges are built oblique to the stream, with the draw in the up-stream end, leaving a natural tendency of the water to choose the opposite end. The draws are narrow, and require considerable current to keep them clear, and if sufficient current is produced to keep them clear of sand, as was the case of the Lone Rock bridge, where the improvements of last summer made 10 feet under the bridge, I found that when the boat entered the draw up-stream, and had fairly entered, it became entirely unmanageable, as it completely closed the draw and stopped all the water, except what it floated in.

The Spring Green bridge-draw is now nearly dry at ordinary stages of water.

The river is subject to considerable periodical fluctuations. The termination of winter causes a slight rise after the ice has left the river; the melting snow and spring rains cause a June rise, and the September rains another. The regularity failed in 1871, the end of winter and June rise being a continuation. The latter rains failing, the river continued falling till near the end of the season. This spring nearly the same. The freshets are governed by the Dells, a narrow gorge, 67 feet (measured) at the narrowest place. A sudden rise of short duration, but of considerable magnitude, is but little felt on the river, while a less rise of some duration causes high water. Annexed is a sketch of the variations of water at the Dells, and compared with Portage City.

The work of experimental improvements was commenced on the upper and middle proposed canal-crossings. In both cases, the absence of materials in the immediate vicinity required considerable improvement in addition to the actual work first contemplated.

The first dam, No. 1, five miles below Portage, on the upper crossing, was built in part, but not entirely completed until late in the season. No. 2, which should have been built second in order, could not be commenced until October. The intervening time was occupied in improving the river between the materials and the first dam.

During July materials were prepared for the middle crossing, but in order to obtain the required materials it was necessary to repair the river at the bridge, which was impassable.

No. 1 dam was commenced in August, and the work continued on this portion of the river until October, before the required dam, denominated 10, could be commenced, and completed late in the season. On the opening of the present season, the work was directed to the river-bed, regardless of the canal-plan. The upper party commenced operations on Allen's Flats, being a continuation of the last season's work, and the lower party commenced operations at Muscoda, working from there toward Richland City, the object of the work of the present season being to produce a 3-foot channel so far as the available funds would reach.

Amount of work done during the fiscal year: 10,796 feet of dam constructed; 1 steam-scow built, 70 feet long, 16½ feet wide; 4 stone-scows built, 70 feet long, 17 feet wide; 2 stone-scows built, 45 feet long, 13 feet wide; 3 river-scrapers constructed; 1 quarter-boat commenced; and the general repairs of United States boats, and of tools and implements, as necessity required.

Total expenditure during the year on the work, and which does not include stationery, office-furniture, or rent or mileage, viz		$58,156 91
From which deduct for cost of constructing scrapers	$333 04	
Building and repairing scows and boats	7,624 75	
Tools and implements purchased	373 17	
Repairing boats and United States property	1,131 84	
General repairs of tools and implements	291 91	
Purchase of boats	6,250 00	
Miscellaneous	1,110 14	
Total deducted		17,114 85
Net cost of work on dams		41,042 06

Annexed is a detailed statement of expenditures for the twelve months:

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Cost of labor, material, boat-hire, &c., expended on the improvement of the Wisconsin River during the fiscal year ending June 30, 1872.

Class of expenditure.	1871. July.	August.	September.	October.	November.	December.
Engineer and superintendents	$384 00	$612 00	$577 50	$647 00	$755 00	$523 6
Boat-hire	1,345 00	1,982 87	1,935 00	1,901 25	1,559 25	.....
Fuel for boats	54 75	133 94	59 46	167 06	223 50	.....
Crew of boats	79 16	135 00	105 00	105 00	105 00	.....
Subsistence	71 50	97 00	80 50	87 00	182 50	.....
Labor	690 37	2,022 35	2,560 08	2,391 14	2,175 61	319
Teams				99 00	563 25	33
Materials	295 54	940 44	1,552 83	1,939 55	474 05	.....
Watchman on snag-boat	60 00	60 00	60 00	60 00	60 00	60
Purchase of boats						
Total	2,980 32	5,983 60	6,930 37	7,397 00	6,098 16	935

Class of expenditure.	1872. January.	February.	March.	April.	May.	June.	Total
Engineer and superintendents	$647 00	$623 00	$823 00	$815 00	$800 50	$815 00	$ 022
Boat-hire				230 00	240 00	660 00	9 53
Fuel for boats				46 50	280 72	347 55	1 313
Crew of boats				36 00	461 33	562 31	1 58
Subsistence				23 00	137 95	188 62	68
Labor	178 81	158 75	538 75	1,005 74	2,050 59	3,175 39	17 26
Teams	33 00	55 50					7
Materials	22 00	163 64	473 45	915 28	2,306 49	2,507 09	11 39
Watchman on snag-boat	60 00	60 00	60 00	60 00	20 00		6
Purchase of boats					6,250 00		6 25
Total	940 81	1,060 89	1,895 20	3,131 52	12,547 58	8,255 96	5 15

To show the effect of the work I annex Tracings A and B.

Tracing A, the place of operations of the upper party, shows six miles of improv river, with only two places where there is not a reliable 3-foot channel, one at t lower end of Allen's Flats, which will correct itself in a short time. The one abo Dekorra will require the work shown in red. The principal part of the channel above 4 feet, whereas the working-boats had great difficulty in moving about l season.

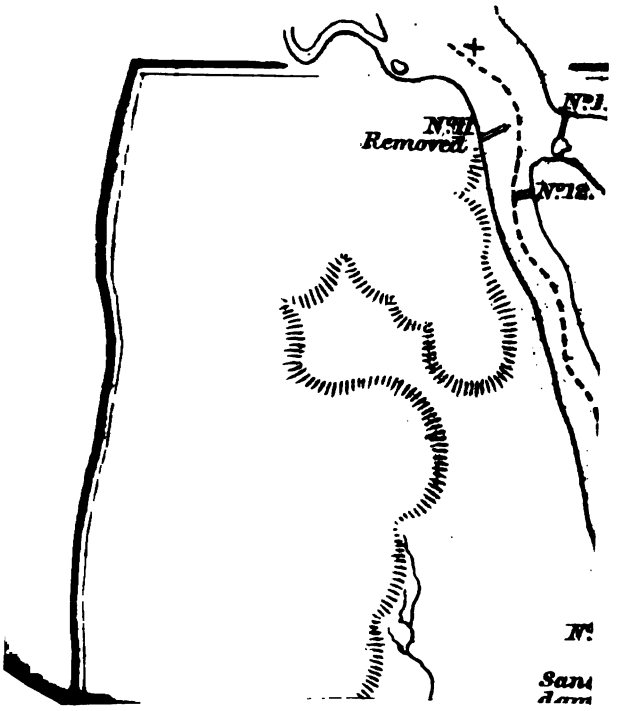
Tracing B shows the operations of the lower party. From Otter Creek to Indepen ence, four and a half miles, operations of 1871 give practically a 4-foot channel.

From Bogus Bluff to Muscoda, six miles of operations of 1872 give a reliable 3 fo channel, with the exception of two places, which the work done will corect. Asi from the two shoals, the channel is from 4 to 5 feet for the greater part. The figur are given for low water at 0.90 above lowest water known. Where the water is l than 3 feet the depths are marked on both tracings. The red color shows the wo proposed.

Dam No. 11, on upper end of Tracing A, was removed. The dam was built for t purpose of making a 5-foot canal-crossing. This it had done effectually, but elevat the water so much at ordinary stages as to force a volume over Dam No. 1 opposi with considerable current, requiring either the raising of No. 1 or the removal of N 11. The latter was done, but with the greatest difficulty imaginable, the sand a brush being so intermingled as to be difficult of separation.

Concerning the stability of the dams not the slightest doubt remains. I mention in my final report on the experiments of last year, that I considered the test whi they (the dams) withstood when in that particular stage of progress, when the wa poured over the same in one entire sheet, as much severer than any resulting fr high water. But a severer test remained. Before the ice broke in the river the da

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were open about 10 feet above and below, the water rushing with great violence from under the ice in front, and disappearing like a torrent under the ice behind. Still a severer test came with high water. I took it from good authority that, as the height of the water over the obstructions would increase, the disturbances would decrease; but this was not the case. As the water rose the disturbance increased, so that, in some cases, with 4 feet of water over the dam, the sand was excavated from 12 to 16 feet deep in continuation of the slope of the back of the dam, which again filled as the water receded. None of the dams were disturbed. Appended is a diagram of water-ganges for the year, reduced to the lowest water of 1871.

Respectfully submitted.

JOHN NADER,
Assistant United States Engineer.

Captain A. M. MILLER,
United States Corps of Engineers, Milwaukee, Wisconsin.

PORTAGE, *July* 13, 1872.

The work will be continued during the present season, and the funds available will be exhausted.

It is believed that the practicability of the plan of improvement has been sufficiently proved by the operations up to this time, and an estimate of $250,000 is submitted for the fiscal year ending June 30, 1874.

Amount available July 1, 1871	$106,902 95
Amount expended during the fiscal year ending June 30, 1872	55,781 92
Amount available July 1, 1872	51,121 03
Amount required for fiscal year ending June 30, 1874	250,000 00

Respectfully submitted.

D. C. HOUSTON,
Major of Engineers, United States Army.

A 21.

IMPROVEMENT OF THE WISCONSIN RIVER.

UNITED STATES ENGINEER OFFICE,
Chicago, December 28, 1871.

GENERAL: I have the honor to submit the following report of operations on the improvement of the Wisconsin River during the past season.

On the 10th of June, 1871, I submitted, in compliance with your instructions, the following project of operations, which was made after a consultation with Major G. K. Warren, Corps of Engineers, under whose direction a survey of the Wisconsin River was made in 1867:

WASHINGTON, D. C., *June* 10, 1871.

GENERAL: I have the honor to report that I have seen General Warren, and examined the detailed maps of the survey of the Wisconsin River, with a view to preparing a project for the expenditure of the funds available for the improvement of that river.

I find, upon consultation with General Warren, that it will not be practicable to submit at once a detailed project for this purpose, for the reason that the bed of the river is constantly shifting, and that a very different state of things may now exist from that shown by the survey made four years ago.

It will therefore be necessary, in order to locate exactly the works of improvement, to make a re-examination of the river at those points where improvements are designed.

The object to be had in view, in expending the present appropriation, is to test the practicability of improving the navigation of the river itself, without resorting to slack-water navigation or to a canal.

General Warren has laid down, upon the map of the river, a canal-route, from Portage City to Prairie du Chien, which he recommends as the most practicable plan for obtaining a reliable navigation from Green Bay to the Mississippi River.

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The canal crosses the Wisconsin River at three points, where it is proposed to make use of the river. At these points it will be necessary to improve the river-channel, and it is proposed to use the means now available in attempting the improvement. The works required in improving the navigation of the river should be designed, first, to so direct the current as to insure a permanent channel-way. This can be done by protecting the banks and constructing wing-dams.

In order to illustrate, without further loss of time, the general character of the work to be done this season, I inclose Sheet No. 13 of the survey, giving in pencil the location of the second canal-crossing, and a proposed location of the works and wing-dams for giving direction to the current. The precise location of these dams can only be determined upon the ground, as the course of the river has probably changed. This is the worst crossing, and where I propose to commence operations. What I would propose is to go upon the ground, taking with me the person designated as superintendent of the work, and, after consultation with parties familiar with the river, locate the dams.

The dams should be constructed (I think now) of brush and stone, and I would employ men accustomed to this kind of work. In order to economize in time and labor, the materials should be obtained from the nearest locality, and what purchases are necessary should be made without resorting to the contract system, which, for work of this character, cannot be resorted to without serious delays and interruptions.

It is supposed that, in many instances, the materials can be procured at simply the cost of moving them, so that the main expense will be that of labor. I would propose this plan for the preliminary operations at least.

I would respectfully request an order to visit Portage City, Wisconsin, with a view to employing a vessel (if necessary) to make a personal examination.

Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

The project of operations having been approved in your letter dated June 12, 1871, I proceeded to carry it out.

I had hopes that, before commencing this work, I should have received copies of all the maps and records of the survey, together with the final report of Major Warren, giving his views and the results of his observation and experience. As, however, it was proposed to limit the operations of the season to the improvement of the river at the points where the proposed canal was to cross the river, and the operations incidental thereto, it was not absolutely necessary that I should have more of the survey than referred to these points, and these were furnished in detail, together with a general map of the river on a scale of 10 inches to the mile. The detailed map of the river was on a scale of 200 feet to 1 inch, and comprised twenty-four sheets; of these I received seven sheets especially referring to the locations above mentioned.

The work to be done was to improve the navigation of the river at the points where the proposed canal was to cross the river, and in so doing to determine the practicability of improving the navigation of the river itself. The proposed canal starts from a point on the canal now connecting the Wisconsin and Fox Rivers, near Portage City, and proceeds on the left bank of the river to a point about $4\frac{5}{8}$ miles below Portage City, where it connects by a lock with the river. The canal then commences on the opposite bank of the river and proceeds on the right bank to a point about $56\frac{1}{8}$ miles below Portage, when it again connects with the river by a lock. Commencing again on the left bank opposite, it proceeds to a point $88\frac{5}{8}$ miles below Portage, when a similar crossing becomes necessary, and then proceeds on the right bank to Prairie du Chien, when it connects with the Mississippi River, 106 miles from Portage.

The depth of the proposed canal is for vessels drawing 5 feet, and the length of the river to be improved, to enable boats navigating the canal to cross the river, is, at the upper crossing 2,300 feet; at the middle crossing, 7,000 feet; and at the lower crossing, $2\frac{1}{2}$ miles.

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It was proposed to commence work at the middle crossing, but the navigation of the river by boats of any class had been closed at the railroad-bridges of the Milwaukee and Saint Paul Railway, near Spring Green and Lone Rock. Work was therefore commenced in July at the upper crossing, and the first operation was the construction of a dam of brush and stone, 700 feet in length, at a point just below the crossing, and designed to close up one channel of the river here, divided by islands, and to confine all the water of the river into one channel.

The drawings accompanying this report show the method adopted in building this dam, which was generally followed in all subsequent work. The crest of the dam was placed about one foot above the low-water stage, it being only designed to confine the river during the season of low water, and to allow the water during freshets to pass freely over the dams.

The brush used in building this dam was obtained from the islands in the vicinity, and the stone from a point below Dekorra, two miles below the dam.

This dam is marked Dam No. 1 on Tracing No. 1, accompanying this report.

Our works having been confined to the upper and middle crossing, I will first describe those at the upper crossing, shown on Tracing No. 1. It was proposed, after the construction of Dam No. 1, to build a dam on the opposite side of the river, so as to confine the current and cut out a channel on the line of the crossing; but the effect of Dam No. 1 was to so alter the current below as to cause a shifting of the bars, and interrupt navigation between the point of operations and the source of one class of our material, stone. It was then determined, if possible, to improve this portion of the river for a distance of two miles, so as to admit the passage of our boat. Accordingly, the dams marked Nos. 2 to 9 were successively constructed.

On the 15th of September I visited Dekorra, at which time all the dams above mentioned had been built, except Nos. 7, 8, and 9. I found that the steamer engaged in carrying materials could not pass over the bars at Dekorra. I then directed the construction of Dams Nos. 7 and 8, and the T to No. 3. The river here is straight and wide for a distance of 1½ miles. It is one of the worst portions of the river. It was a good opportunity to test the efficacy of wing-dams or dikes, and it was necessary to do something or the work would stop for lack of materials. The effect of Dams Nos. 3 and 8 was very marked, and resulted in a channel through the bar full 4 feet deep, when before there were only 2 feet. The channel in that portion of the river where the dams have been built is now 5 and 6 feet in depth.

There seems to be no doubt that by an extension of the system which has been adopted any required depth of channel can be obtained.

In order to carry on the improvement at the lower middle crossing, 1½ miles below the Lone Rock railroad-bridge, a steamer was sent down from Portage and encountered a serious obstacle at the railroad-bridge near Spring Green.

The direction of this bridge, as well as that at Lone Rock, makes an angle with the direction of the river, so that the bridge-piers offer a great obstruction to the current, and act as dams to throw the current toward the lower end of the bridge. The draws of these bridges were placed at the upper ends, where, at the time they were built, there was found the deepest water; but they were almost entirely filled with sand at the commencement of our operations. By putting in a small wing-dam, so as to turn a portion of the current through the

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draw, and removing the sand in the draw with a common scraper, the boat was passed through the Spring Green bridge. At the Lone Rock bridge the draw was not only closed, but a large, dry sand-bar was found immediately above it. In order to open a channel through this bar the dams shown on Tracing No. 2, and marked Nos. 1, 2, and 3, were constructed. As it was the season of extreme low water, the effect of the dams was not as rapid as was wished, but the ultimate effect of confining the current and changing its direction was to cut through the sand-bar and open a deep channel through the draw. The Dam No. 9 was then put in to open a channel below the bridge to the site of the middle canal-crossing, after which Dam No. 10 was constructed. This dam and a proposed dam below are the principal works designed for this crossing, but navigation closed before the latter dam could be put in.

No work was done at the third or lower crossing, as we were not able to get boats there without considerable delay; but as the character of the river is the same at that point, the practicability of improving it will be determined by the results of the works at the other points.

The Tracings Nos. 1 and 2 show the condition of the river before and after the improvements were made. Tracing No. 3 shows the variation in water-level during the season of operations, and Tracings Nos. 1 and 2 the details of the dams.

I also inclose plans of the scraper used, which is the same as that now in use on the Upper Mississippi, and a photograph showing it attached to the steamer. This scraper was not used until late in the season. Its cost was $150, and it can be attached to any steamer. Its use will greatly facilitate our subsequent operations. The draws of the bridges over the Wisconsin, particularly those of the Milwaukee and Saint Paul Railroad, which cross the river obliquely, will require to be enlarged and improved, should the project of river-improvement be carried out. They are at present wide enough for the passage of vessels which navigate the Fox River, the locks on which are 35 feet in width, and it is not deemed necessary that any extensive changes should be made until the character of the improvement is finally decided upon and the work more advanced.

It will be necessary to remove the stone in the draws, which has been placed there to protect the piers, and to put in pile-protection above the draws, to facilitate the passage of vesels and prevent injury from collisions. This, no doubt, the railroad authorities will attend to when called upon, as they have shown every disposition to facilitate the progress of our work.

The cross-section of the river at Portage is, at low water, 1,447 square feet, having a width of 700 feet, and an average depth of about 2 feet. The velocity is 1.91 feet per second, giving a discharge of 2,764 cubic feet per second. In many places the river is much wider, with a much less depth.

The problem of improving the navigation of this river is to contract the channel, so as to obtain at low water a greater depth. If we put in a dike extending from one bank of the river, say half-way across, the effect is to cause a rise above, and an increase of velocity at the point of construction, in consequence of which a channel is scoured out through the light and easily moved sand composing the bed of the river. This cutting out will go on until the velocity at the bottom is reduced to a point not sufficient to move the sand. The sand moved by the current is deposited in the eddy formed below the dike.

The mean velocity of the water in the contracted portion is greater

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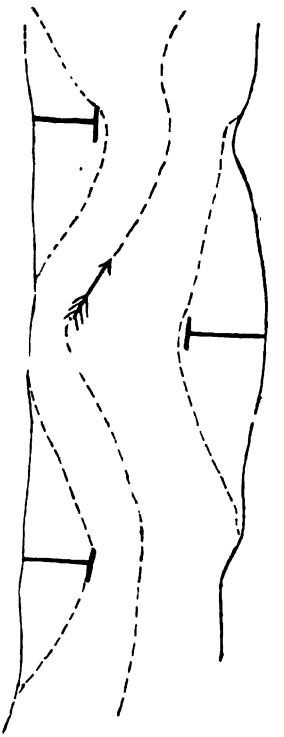
than above, as it depends not only on the inclination of the surface, but upon the friction of the sides and bottom, as shown by the hydraulic formula—

$$V = M, \sqrt{ir} - N$$

in which the variable quantities are i, the inclination of the surface, and r, the quotient obtained by dividing the area of the cross-section by its wetted perimeter.

As it is important that the velocity of the river should not be increased, in the interests of navigation, it follows that if we increase r, as we do by the contraction, we should diminish i; in other words, increase the length of the stream.

To accomplish this, it is proposed to place the dikes as shown in the marginal sketch, projecting alternately from each bank. The effect of dikes so arranged is to cause the sand to deposit above and below, forming a new bed, as shown in the figure.



The actual disposition of the sand, caused by the dikes, is shown by the fine dotted lines on Tracings Nos. 1 and 2.

In actual practice, it will not be possible to place the dikes with mathematical precision, but the principle above stated will be adhered to.

It has been found necessary in practice to place T's and L's at the end of the dikes, in order to prevent undermining by eddies. The length of the dikes, and their distance apart, are to be determined by experience. At Dekorra, where the river is 700 feet wide, the dikes are 200 to 300 feet long, and placed 1,000 feet apart. Experience and theory both show that the effect of these dikes will be to form a channel, the depth of which will depend on the amount of contraction. In addition to the dikes it will be necessary to protect the banks of the river at those points where the current strikes them. This protection can be readily effected by brush and stone. If we suppose the channel to be confined as described, we are next to consider the influences to which it and the works confining it are subject. The characteristics of this river have been fully described by Major G. K. Warren, of the Corps of Engineers, whose report is attached to the report of the Chief of Engineers for 1868. The bed of the river is composed almost exclusively of a yellow sand, weighing about 87 pounds to the cubic foot when wet. This sand is moved by the current, forming bars, which have a very gentle slope on the up-stream side, and very steep on the down-stream side. The sand is pushed by the current up the up-stream slope until it reaches the summit of the bar, when it then falls. The consequence is that these bars are continually moving down stream. Their crests assume every conceivable position with relation to the course of the river. Sometimes the entire bar is on one side of the river, and in this case a good channel is always formed between the bar and the opposite bank.

In this case all that is necessary is to make the bar permanent, by placing brush and stone on the up-stream side. But when the bars

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extend from bank to bank, the channel is very shallow, and the river is not navigable at low water.

The effect of freshets on this sandy bed is to flatten out the bars, and when the river subsides it seeks a channel where it finds the least resistance, and thus changes after every freshet. This will be obviated by the works of improvement.

Every freshet brings down large quantities of this sand from the upper waters of the Wisconsin. The banks of the river at several points are composed of this material, and are 25 feet or more in height. An examination of these points has been made, and it is found that the banks wear away with every freshet. It will be necessary to arrest this action, either by changing the course of the river, or by protecting the banks. If the channel of the river below Portage is contracted by dikes in the manner above described, what is to become of the sand brought down from the upper river? At present it is moved down in the shape of bars, and carried to the Mississippi. The effect of the dikes will be to cause deposits on either side of the channel, and, if the supply of sand continues, to form new banks. When these banks reach a certain height, the sand coming down will contract the channel, causing a rise of water and spreading out of the channel. The sand will then deposit at the bottom, and the whole bed of the river be raised.

It is probable that the bed of the river at Portage, where it is higher than the land on either side, was raised by this power. I think it will be possible at a moderate cost to greatly diminish the quantity of sand brought down.

One effect of freshets which overflow the banks of the river is to cut out new channels and cut away the banks. It is observed that this action is gradual, and can easily be prevented if attended to in time.

The effect of ice upon our works will be shown the coming spring. It is not thought that they will sustain any material injury, as similar works have withstood the same exposure. The water is about 2 feet above the dams during the breaking up of the river.

It is probable that in locating the dikes it will not always be possible to place them exactly where they should be, and that the channel will not always be cut out as anticipated. It is therefore proposed to use scrapers attached to steamboats as an auxiliary in this work.

A plan of the scraper, which has already been used with success, accompanies this report.

The total length of dikes and dams built during the season is 6,600 feet.

The total expenditures are $30,000, making cost of dams about $4.50 per foot.

By the experience gained this season this cost can be reduced to $3.50 per foot.

The total length of dams and dikes necessary for the improvement of the river is 84,584 feet, which, at $3.50, would make the cost of the improvement	$296,044
For maintaining channel, removing snags, &c., expenses of the boats for four years	100,000
Cost of improvement on upper river to stop sand	30,000
Total	426,044

This estimate is about the same as the estimate for the first plan of Major Warren. I feel no doubt that by the system of wing-dams a re-

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liable navigation of at least 4 feet, and in all probability 5 feet, can be obtained.

The following papers and maps accompany this report:

Reports of Assistants J. Nader and John Pierpont.

Two tracings, showing condition of river before and after works of improvement.

One tracing, showing variation in water-level during season of operations.

One tracing, showing sand-banks on river above Portage.

One photograph, showing scraper used near close of season, and proposed to be used next season.

The tracings are sent by express.

Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

WISCONSIN RIVER IMPROVEMENTS.

Report on the formation and present condition of the Wisconsin River; examinations and surveys; also experimental improvements, and results thereof, made by the United States Engineer Department, under direction of Colonel D. C. Houston, United States Corps of Engineers, from July to December, 1871.

The necessity of improving the Wisconsin River need not be dwelt upon in this report, as the same has already been set forth in numerous memorials and reports to its fullest extent; and to consider the vast territory susceptible of improvement and development in immediate connection with the river, is alone sufficiently convincing of the necessity of the scheme, and of the national character which the same should and will assume.

Careful examinations and surveys have been made with a view of making reliable navigation from Portage to the Mississippi. Several projects have been made, but as yet none had been adopted, as there were no reliable data at hand upon which to base the least expensive plan, that of improving the river-bed itself, and it was determined to make a series of practical experiments on the improvement of the river-bed before adopting the most reliable, yet at the same time most expensive plan, that of navigation by canal.

During the past season a number of experimental dams were built, the construction and result of which will be the special subject of this report.

Before entering upon the engineering question involved in the subject, it may be well to seek the source of the difficulties which are to be overcome, by examining into the location, general formation, and present condition of the Wisconsin River, including the upper river; that is, that portion of the river from its source to Portage.

The river has its source in the northern part of the State, and runs nearly due south to Portage, where it turns abruptly and flows about west-southwest to the Mississippi. There is very little uniformity in the general features of the upper river; the source is in a slightly rolling ground, with extensive marshes; the river-bed is for the most part rocky, until the bottom-land gradually changes to a more rolling and uneven country, which rises very gradually on both sides of the river; the hills gradually increase in height and line the river-banks on one side or the other (never on both) as far as Germantown; occasionally soft sandstone rock crops out on the surface or near the river-bank. Below Germantown the country is more hilly, and slopes more quickly from the river until reaching the Big Dells, where the river runs between rock-bluffs, and again at the Dells, where the river is confined to a narrow gorge, at one place less than 60 feet in width; from the Dells to Portage the ground is generally low with but few hills, and overflowed for a considerable distance during freshets. Immediately below Portage the valley presents more uniformity in its formation, and four distinct stages are defined nearly the whole distance to the mouth.

The first is the bed of the river proper, being a sand formation almost entirely; at a few places an outcrop of soft sandstone is found, but to no extent.

The next stage is the bottom-land, being pure sand, with a slight covering of decomposed vegetation, and overgrown with timber; also numerous islands of the same

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formation; the bottom-land and islands are generally overflowed at times of high water.

The third stage is the sand-terrace, from five to fifteen feet high, and forms a level plain to the bluffs which are the limits of the valley; at some places the river flows at the foot of the bluff on one side, at others, again, along the terrace; where the latter takes place, there is a rapid wearing away of the bank, and the sand is carried along some distance and forms bars. The sand-banks on the upper river appear to be the source of the numerous sand-bars which fill the river from there to its mouth; at very high water a portion is carried off and deposited somewhere along the river. The distance to which the sand is moved depends entirely upon the duration of the freshet; furthermore, as the river-banks abound in timber, a number of trees are carried into the river every season by the wearing away of the banks, and form snags, which form a great annoyance to the rafting of timber from the upper river and its tributaries.

My attention was first called to the existence and extent of these sand-banks by Mr. Joseph Ludwig, of Portage, and upon inquiry his statements were corroborated by a number of river-men. As the matter was considered important in connection with the improvement of the river, a special examination was ordered, and intrusted to Assistant J. Pierpont; a detailed report of his work is hereto appended.

The result of the examination is quite satisfactory, and proves beyond a doubt the origin of the sand-bars.

Having found the source of the difficulties, the next thing of importance is to examine their formation and movements. Wherever the river is contracted between narrow banks, the sand-bars will form only behind projections or obstructions, and in this case tend to improve rather than obstruct the channel; also occasionally, where the river is moderately wide, sand-bars are found to have lodged on one side or another, (probably caused by some obstruction,) and preserve a good channel; but where the stream is straight for some distance, and of considerable width, there will be formed a middle ground, with but little water over the same, and sometimes a dry bar; in either case the channel is on one side or the other, never on both, to my knowledge.

The greatest difficulty occurs where the middle ground is flattened out, and extends across the whole width of the river; in such cases generally one side of the bar advances more rapidly than the other, and the crest of the bar is formed obliquely across the river; the current generally flows at right angles with the line of the crest, and the width of the river is virtually nearly doubled in some cases; in nearly every case, deep water is found along the crest of the bar, and in those partaking of the character last named, the deep water continues to the river-bank at the short end of the bar, and as the bar advances the water becomes deeper at the bank, and forms a gorge, where a vast body of water flows off almost imperceptibly, excepting that it undermines the banks very rapidly, letting down large pieces of the sand, together with the trees and timber.

As to the motion of the sand-bars, it is found to be quite regular, and appears to depend not so much on the stage of the water as upon the rapidity of the change from high to low, and upon the velocity of the current. Generally, during a continuous stage of water, the movement is slow and regular, and the bars appear to be moved along by the pressure as an obstruction rather than by the velocity of the water; whenever moved by the velocity of the water, they move quite rapidly, and the sand is found floating in the water in quantities, whereas in the other case no sand is found floating, but slowly and steadily rolling along the bottom until something disturbs the equilibrium. As an instance, I will mention a bar above Steamboat Slough, containing a uniform depth of water of 22 inches at a certain stage of water. After the water had fallen 12 inches, the same amount was found; also subsequently, when the river had risen again a little above its former stage, still the same amount of water covered the bar, clearly indicating the existence of equilibrium between the current and weight of sand.

In order to determine the most favorable condition of equilibrium required to preserve a good channel, a section was measured near Lone Rock, where the channel is quite uniform for several hundred feet, and the stream at low water is confined to one channel of 325 feet between banks; the greatest depth was 7.4 feet, and the mean depth 6 feet, giving the cross-section of 1,950 square feet; a series of floats gave a mean velocity of 1.95 miles per hour; the channel in question always preserves a uniform depth, and is free from sand-bars. An examination of General Warren's maps, of his survey of 1867–'68, will show many similar places on the river, from which it will be safe to assume the necessary section for any required depth of water.

Aside from the sand-bars, the only other obstructions to navigation on the river are the railroad-bridges, and the principal difficulty with those is, that they are built obliquely across the stream; the water is thereby inclined to flow to the bank at the down-stream end; whereas the draws of both the Spring Green and Lone Rock bridges are at the opposite or up-stream end; in addition to this the draw-spans are very narrow, and still more contracted by the piles and riprap protection of the pier-foundations, making the entire available width at low water about 36 feet only; and if the river is improved, it will require the rebuilding of almost every bridge on the river.

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EXPERIMENTAL IMPROVEMENTS MADE UNDER DIRECTIONS OF COLONEL D. C. HOUSTON, UNITED STATES ENGINEERS.

After a preliminary examination and the necessary preparations, the work was commenced on the upper proposed canal-crossing on the 26th of June, and during July the first dam was completed, excepting stone covering. The dam is 700 feet long, and is located opposite the mouth of the Baraboo River, from the head of Pine Island to the left river-bank, and is denominated No. 1 on accompanying map. Owing to the absence of materials above Dekorra, and the impossibility of bringing the same from there to the work, on account of moving sand-bars, the dam opposite the first, now denominated No. 11 on the map, could not be built, as was proposed at the time, and the second dam, No. 2, was commenced and built from the first island below Dekorra to the left bank. The dam is 400 feet long.

No. 3 was next taken in hand to narrow the river near Dekorra; this was lengthened from time to time, until it reached its present length of 300 feet, which appears to leave the proper width between the end of the dam and left bank, (450 feet;) a T was built at the end of this dam to give direction to the current.

Next a rope-dam was built between a small island and the right bank, 165 feet long; this was done by stretching a rope across the interval and placing brush upon the same with the butts upon the rope, and the tops up stream on the sand; subsequently the rope was removed, and by placing stone upon the brush the dam was made permanent. It is shown as No. 4 upon the map.

About this time the bank opposite the last-mentioned work was being cut away very rapidly, and a dam 80 feet long, denominated No. 5, was built to protect the same.

Next a wing-dam, No. 6, was built from the island opposite McDonald's Eddy; it was first built 70 feet to deflect the current and protect a dry sand-bar below, but was subsequently lengthened 100 feet to give the desired effect.

A large quantity of water was found flowing off through a channel or gorge in McDonald's Eddy; this was leaving a middle ground, which it was desirable to remove, and the gorge was stopped by a rough dam 100 feet long.

As it was desirable to try the effect of wing-dams on alternate sides of the river, Nos. 7 and 8, each 200 feet long, were built. Two short dams, No. 9, 50 feet long, and No. 10, 90 feet long, were built to protect the river-banks, and to arrest moving sand disturbed by the other dams. Up to this stage of proceedings the work of this party was a continual strife to keep open communication between the place below Dekorra where the material could be obtained, and some place where it could be used to advantage, but now the work completed left a good channel to the mouth of the Baraboo River, and materials were brought up, and the Dam No. 11 built and perfected. The dam is 370 feet long, and located on map.

Another dam, 100 feet long, was built a little below and on the opposite side from the last mentioned, as shown on map as No. 12. Here the severity of the weather put a stop to further operations, and the works closed on the 21st of November.

During the latter part of July a steamboat was gotten as far as Lone Rock, and a working party organized for the work on the proposed middle canal-crossing.

The railroad-bridge and a bad flat, both above and below the same, lying between the material and the proposed work, which obstructions it was impossible to pass without some improvement, consequently Dam No. 1, 756 feet long, was constructed, as shown on the map. Dam No. 2 was next built to close one of the channels at low water; the dam is 460 feet long, reaching from the head of Paddleford Island to the right river-bank.

A dam denominated No. 3 was next built, as shown on the map; length is 1,200 feet. Simultaneous with No. 3, two short dams, 4 and 5, for shore protection, were built, being respectively 60 and 65 feet long. At the present stage it was found necessary to protect the river-bank at the shore-end of Dam No. 1, and at the upper end of a small slough near the lower end of Paddleford Island.

Next a dam, No. 6, 65 feet long, was built to protect the bank from the increased current from the dam on the opposite side. After protecting the head of Paddleford Island, and not being able to get a passage through the draw, a dam, No. 7, 100 feet long, was built, to protect the river-bank opposite the mouth of Otter Creek; also, one a little below, on the bank of the island, No. 8, 60 feet long.

A wing-dam, 70 feet long, was built for the protection of the center pier of draw, up stream, to guide as much water as possible into the draw. The dam is only temporary, and may probably require to be removed after the channel has corrected itself.

A wing-dam, 110 feet long, No. 9, was built on the right river-bank, below the bridge, to obtain a channel through the bar at that point; and on the 30th of October the party was enabled to make a commencement on Dam No. 10. The distance is 680 feet. The work was continued on the whole length until November 18; and from this time to the 28th, when the work closed, the work was directed to the permanence of the dam, excepting a gap, which had been left to let the United States steamer Winneconne and boats through, which were being brought up from Prairie du Chien, and

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would not have been able to get up the other channels. The boats passed on the 22d, but, on account of drift-ice, nothing further could be done on the part of the dam, which now remains unfinished, but perfectly safe, as there is a foundation of two courses of fascines, securely anchored with stone and gravel.

PLAN OF CONSTRUCTING WING-DAMS.

The plan adopted required only the use of brush, with sufficient stone to retain the same in place, and the addition of gravel to prevent leaks under the brush. The brush was made in fascines of 10 feet long and 12 to 15 inches in diameter, securely bound. The fascines were then formed into mats of about 9 feet wide, by placing a number of fascines side by side, and placing light poles on top and bottom, and tying the ends of the poles with twine. Having determined the position of the dam with stakes driven into the sand, a sufficient number of mats were prepared as above stated, and a quantity of stone and sand-bags being in readiness, the work was commenced. While the weather was warm several of the men would get into the water to place the mats in position; afterward the same was done from scows and boats. The mats were floated into position and sunk by placing stone and sand-bags upon the same. They were placed side by side in the line of the dam, and the bottom row carried to the entire required distance; the brush-ends or tops were placed up stream, and after the first course was laid the tops were covered with a layer of gravel to prevent undermining, and the carrying up of the dam to the required height was proceeded with according to the depth of water; sometimes two or more courses were carried forward together, but upon approaching the surface it was found advantageous to carry the whole up uniformly, so as not to concentrate a rush of water to any one place; each course was brought forward from 2 to 4 feet, in order to allow the next lower one to project out behind, upon which the falling water would impinge, and its force be broken.

After the dam was carried in the above-described manner a little above low water, a substantial layer of loose brush was placed along the entire face of the dam, and covered with a layer of stone, and then with sufficient gravel to stop all leaks. A cross-section of dams is shown on accompanying map.

To facilitate the work on the improvements, it was necessary to build one skiff and three scows.

The scows were built of pine. One is 45 feet long, 14 feet wide, and 22 inches high: the other two are 70 feet long, 17 feet wide, and 42 inches high. Both are provided with spuds, or growsers, and one was supplied with stern-wheel, steam-engine, and boiler, for the purpose of operating in shallow water, but was not completed in time to be put to work with safety, from the severity of the weather; the boat was allowed to make a trial trip, which was very satisfactory, and was then laid up.

A scraper, of which plans were submitted in October, was constructed and attached to one of the working-boats, and operated with much satisfaction; the boat was thereby enabled to make its way to any desired point without any difficulty.

The whole number of dams built is 22, ranging from 50 to 700 feet long; one is 1,200 feet long, but answers more as a longitudinal than a wing dam.

The following is an account of the expense of the work to December 1, 1871:

The total length of twenty-two dams is 6,621 feet.

Cost of labor and materials expended on construction of dams.

235 days' hire of steamboats	$8,150 00	
142½ days' hire of scows	213 37	
Fuel	452 96	
Crews	451 32	
Subsistence	373 00	
Supplies	5 60	
Total boat-hire		$9,646 25
5,387 days laborers	8,290 75	
220¾ days teams	662 25	
Total labor		8,953 00
855 cords stone	2,317 36	
500 cubic yards gravel	25 00	
Lumber	21 92	
Sand-bags and twine	143 37	
Total materials		2,507 65
Total for constructing dams		21,106 90

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Cost of scraper.

4½ days carpenters	$11 25
2.1 days blacksmith	8 40
Iron-work	78 74
Lumber	6 84
Total	105 23

Cost of labor and materials expended in the construction of boats.

432.6 days carpenters	$1,060 43
45½ days machinist	137 25
6.2 days blacksmith	15 50
Lumber	714 14
Iron-work	272 37
Hardware	52 57
Machinery	1,128 35
Miscellaneous materials	53 26
Total	3,433 87
Cost of tools and implements	$238 48

General repairs of implements.

12 days carpenters	$29 37
Lumber	81 08
Miscellaneous materials	24 66
Total	135 11

Cost of moving boats from Portage to Lone Rock, and of moving United States boats and property from Prairie du Chien to Lone Rock.

18 days steamboat	$360 00
Crew	77 84
Fuel	165 75
Subsistence	145 50
Machinist	84 00
Pilot	84 00
130½ days laborers	214 75
Total	1,131 84

Summary.

Constructing dams	$21,106 90
Building boats	3,433 87
General repairs	135 11
Manufacturing scraper	105 23
Tools and implements	238 48
Moving boats and property	1,131 84
Watchman	360 00
Total	29,774 93

Summary statement of labor and materials expended.

Assistant engineers	$1,688 00
Overseers	1,368 00
Time-keeper	207 50
Machinist	221 25
Pilot	84 00
Watchman	360 00

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Carpenters	$1,101 05
Blacksmith	23 90
Laborers	8,505 50
Teams	662 25
Boat-line	8,723 37
Boat-crews	529 16
Fuel for steamers	618 71
Subsistence of crews	518 50
Stone and gravel	2,342 36
Lumber	823 98
Iron-work	351 11
Engine and machinery	1,128 35
Hardware, &c	52 57
Tools and implements	238 48
Miscellaneous	226 89
Total	29,774 93

The general effect of dams was the usual effect of contractions; the water was elevated above the contracted part in some cases as much as six inches, but subsided again as the channel accommodated itself to the change.

In the case of cross-dams, a general movement of sand took place for some distance above, and to a considerable distance below the work; and as soon as the current was checked there was a deposit of sand in front of the dam in its whole length.

With wing-dams there was always a considerable increase in the velocity of the current, in one case carrying steamboat and barge over the end of the dam.

As soon as the dams were brought to the surface, there was a rapid deposit of sand above and below the same; the deposit above was concave, and that below convex to the axis of the stream.

In connection with the work, observations were made of the movements of sand-bars, and the effect of the work upon the same. The movement at Portage was from 3 to 5 feet per day, and by comparison this appeared to be the average upon the river, unless disturbances took place. At Dekorra the effect of dams caused a movement of from 7 to 14 feet in twenty-four hours, and at Lone Rock from 6 to 20 feet in twenty-four hours.

The bars moved along at this rate until reaching the dams, and then receded as rapidly and disappeared, the sand being deposited behind the dams.

The general result of the work, as will be seen from the accompanying maps, is very good.

The least reliable water, on that portion of the river near the upper crossing, before the work was commenced was 2 feet, and after the work the latest survey shows the least to be 3.7 feet, practically 4 feet, and still improving.

On the improved portion, near middle crossing, where now the channel is, there was a dry sand-bar at least 1 foot above water; at the time of the last survey there were 4 feet, and improving.

There are of the two portions together about seven miles of river cleared of sand to a reliable depth of 4 feet, and with another dam opposite No. 5, above Dekorra, and the enlarging of Lone Rock draw, 5 feet could be probably relied upon. The work has thus cost about $4,000 per mile, including all expenses arising from the experimental character of the work, and much more so on account of the unusual low stage of water during the season, there having been neither the usual June nor September rise.

From the result of the work it would appear that it is only necessary to contract the stream proportionate to the required depth, everything else depending upon the stability of the dams, of which I have not the slightest doubt, as I consider the test which they withstood when in that particular stage of progress, when the water poured over the same in an entire sheet, as much severer than any resulting from high water.

Concerning the stability of the channel produced, the question arose as to whether high water with increased pressure and velocity would not continue excavating the same until banks and dams would slide in, and the channel become useless; this gave rise to an examination of the river where the same is confined to a narrow channel, so that its depth is from 6 to 8 feet at low water; at such places the bottom is found to be composed of coarser material, and gives considerable resistance to the thrust of a pike; the bottom always remains the same excepting during the passage of a sand-bar during a freshet.

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The following is a table of the weight of sand from different localities:

Number of sample.	Where taken from.	Specific gravity.	Weight per cubic foot.
			Pounds.
1	From bank No. 3 on upper river, (moist)	1.396	87.10
1	From bank No. 3 on upper river, (dry)	1.578	98.46
2	River-bank at Lone Rock, (dry)	1.566	97.09
3	ditto	1.522	94.97
4	River-bank at Dekorra, (dry)	1.469	91.84
5	Bar at Lone Rock, (dry)	1.552	96.84
6	Bar near guard-lock, Portage, (dry)	1.512	94.35
7	Six feet below surface of guard-lock at Portage, (dry)	1.475	92.04
8	Eight feet below surface of guard-lock at Portage, (dry)	1.683	105.02
9	Nine feet below surface of guard-lock at Portage, (dry)	1.646	102.71
10	Eleven feet below surface of guard-lock at Portage, (dry)	1.615	100.77

The last is usually found in digging wells in the vicinity. Samples are sent with this report, numbered to correspond with the above table.

The table of weights shows that the density of the material increases downward.

The results of the experiments and investigations have clearly determined the feasibility of improving the river-bed by means of dams at a comparatively moderate cost.

From the expenses detailed in this report it will be found that from the expenses incurred in the actual work of constructing dams, including engineering and superintendence, the cost of dam has been $3.86 per linear foot; and although the same is moderate, yet it can be reduced very much, from the facility with which the work can now be done, as compared with the commencement, and the improvement which may be made in building dams, although the plan adopted appears to be the correct one.

The following estimate is based upon 36 miles of river taken promiscuously at different portions of the same, and locating the dams in number and extent for a reliable four-foot navigation, but which may possibly turn out five.

In 36 miles of river the number and length are—

Of cross-dams, 41, which equal	10,682	linear feet.
Of wing-dams, 57, which equal	15,020	linear feet.
Of shore protection, 31, which equal	1,980	linear feet.
Giving a total length of dams equal to	27,682	linear feet.
Which, at a cost of $3.50 per foot, equals	$96,887 00	
And gives an average per mile of	2,691 30	
And for the entire river, (say 110 miles)	296,043 00	

I do not think that the actual cost will exceed this estimate, although some of the work will cost considerably more; other portions, again, can be made comparatively cheap; and as some of the dams require only to be built in two or three feet of water, I give an estimate below for a dam constructed of one large fascine, composed of brush on the outside and filled with sufficient stone or gravel to secure the same when placed in position.

The fascines will be three feet or more in diameter, and bound together with hoops. They can be built of any required length up to 70 feet, on scows, or on the river-bank, and afterward rolled upon the scows, which will be brought to the position of the dam and the fascines launched over the side. This idea was suggested to me by a gentleman who had been engaged as overseer on river-improvements in Germany, where the same was used to very great advantage; the same had also been used in stopping breaks in dams and levees.

The following is an estimate for 100 linear feet:

6 cords of brush, at $2	$12 00
1 cord of stone, at $8	8 00
Making, laying, and boats	51 00
Contingent, 10 per cent	7 00
Total cost of 100 feet of fascine	78 00
Cost per linear foot	78

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The above will answer in many places; and at others it will, with the addition of a course of brush and stone covering, costing, in addition, not to exceed $1.50 per foot, make a substantial dam at a cost of only $2.28 per linear foot.

It would be advisable during the coming season to confine the work to the worst places between Portage and Sauk City, a distance of 28 miles, and from Richland City to the mouth, a distance of 48 miles. The probability is that with the money yet available a reliable navigation can be made on those two portions to meet present requirements. The middle portion is obstructed with bridges, which require to be rebuilt before anything satisfactory can be done, and as soon as the work is sufficiently advanced the necessary steps should be taken to cause the removal of these obstructions.

A new railroad-bridge was built on the upper portion during the past season, and is rather an improvement on that portion of the river; the available width of waterway is 250 feet at low water, with a depth of 10 feet; there is one bay, of 132 feet in the clear, adjacent to the right bank, and then follow two draws of 59 feet each; the bottom of the truss is 27 feet above low water, and the roadway 45 feet.

As a final result of the improvement, if the supply of sand still continued, there would be a general elevating of the river-bed; the dams, at their original height, would no longer fulfill their purpose, and the river become as it had been before, and, perhaps, in many places, seek a new channel in the bottom-lands.

From the examination of the upper river, the source of the supply has become evident, and I estimate that about 4,500 feet of dams, at a cost of about $30,000, would stop almost the entire supply; this expense would seem considerable, but I think warrantable, since the ultimate results will certainly be as before stated; and, furthermore, a successful result of the work in hand, and a further development of this portion of the State, and consequent increase of business, could possibly call forth the idea of improving the upper river at no distant day.

I will conclude with a few remarks on the location and direction of dams. The approximate location of a dam is indicated by sand-bars or shoal water; but the precise location must be determined in connection with the desired results above and below for some distance.

The current, driven to the opposite shore by a dam, will most certainly return at some point below, since the dam will cause the surface to become lower on the side adjacent to and below the dam; the elevating of the water on the concave side of the stream will also induce the current to draw toward the same side above the dam, (to the adjacent side.) The above is the result of experiment, and in opposition to the idea of building a slanting dam on one bank to direct the channel to some point on the other, lower down. The best direction to give a dam is to locate the position of the head of the same, and then take the shortest line to the bank; the result is practically the same whether the line be up stream or down, or a normal to the bank.

Respectfully submitted.

JOHN NADER,
Assistant United States Engineer.

Colonel D. C. HOUSTON,
United States Corps of Engineers, Chicago, Illinois.

PORTAGE, WISCONSIN, *December* 26, 1871.

Report on an examination of the Wisconsin River from Grand Rapids to Portage City.

In accordance to verbal orders received October 1, 1871, relative to making an examination of the Upper Wisconsin River, I left Portage City October 3, with two men, and proceeded by wagon to Grand Rapids, arriving the morning of the 5th, and on the 6th started down the river in a skiff.

The Wisconsin River, for about eight miles below Grand Rapids, runs through a rocky region; the bed of the river is very rough and uneven; and bowlders of all sizes jut forth, rendering navigation exceedingly difficult. Attempts have been made, very successfully, to improve these rapids by building wing-dams from either shore toward each other, leaving a gap of from 70 to 80 feet, making water enough for rafts through it, and increasing the depth above. These dams are wooden cribs filled with stone. A number are new; four, on the Whitney Rapids, were built during the last season. An experiment upon the velocity of the water through one of these chutes gave a discharge of 200 cubic feet per second.

The rocks are hard, of igneous character, and without regular stratification. There is no sand whatever in the vicinity.

The character of the river-banks soon changes, the rocks gradually disappearing,

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until, ten miles below Grand Rapids, the first sand-bank appears; this is shown on the extreme upper limit of the accompanying tracing.

The break of the first bar is about a mile below the average annual distance traversed by sand-bars.

From this point down, the river has the same general appearance—low lands on both sides, heavily timbered with pine, decreasing to jack-pine, interspersed with maple, bass, and oak; finally the pines entirely disappear.

There is no defined river-valley. The country from the river on either side is gently rolling, the land-billows generally extending in an easterly and westerly direction, through which the river has cut its way. The valleys between the rolls have a general inclination toward the river sufficient to cause the creeks and brooks to empty themselves, but the velocity of the water in these feeders is comparatively slow.

A short distance below Goodhue's Mill there is a slight indentation in the river-bank, making a distance of 300 feet across to Spring Creek. An attempt has been made to render this secure, but I was informed that at extreme high water last spring a little overflowed. One high rise would be sufficient to send the river through this new channel, and, although it would cut off one large sand-bank, the ground is such that others would be formed.

The sand-bank referred to is shown on the tracing as No. 2. As I was unable to find any section-corners within two and a half miles of the bank, no accurate survey could be made: but from the testimony of the most intelligent of the neighbors, and its present appearance, I should estimate that it has receded 200 feet in the past fifteen years. There is a little clay disseminated through the sand, but not in sufficient amount to prevent its being carried away by the water.

Ten miles below this bank, on the same side of the river, is a mass of rock called Peyton Well. It rises abruptly from the prairie at the water's edge to a height of about 150 feet. The first wire-ferry crosses the river at this point.

About three miles below is a sand-bank, marked No. 3 on the tracing, in character like the preceding. There is a long, narrow island, the upper point of which is on a line with the upper end of the bank. The river is 800 feet across at this point; the greatest depth is 3 feet. The island is separated from the shore opposite by a stretch of dry sand 200 feet across. There is a dry bar near the lower end of the bank, the low-water channel being on the side next the island.

The banks from this point to the Dells are flat and sloping to the river when on the convex of a bend; the concave sides generally having a bank of from 3 to 10 feet in height.

Where the Roche-à-Cri joins the Wisconsin is a bluff of very soft sandstone from 25 to 30 feet high. Below Germantown, at the mouth of the Yellow River, the Wisconsin has a rock bottom, extending about a mile and a half down the river, when the sand again covers it.

At the mouth of the Lemonwier River, a rock-bluff commences on the right hand, and, a short distance below, one on the left. These, called "Big Dells," continue for nearly a mile and a half down the river, when they spread away on either hand.

About five miles below, the river narrows and runs for three miles through a deep rock-gorge, called the "Little Dells." A sand-bar extends into the mouth of the Dells, the water upon which is very shallow. The break of the bar descends to a depth of 30 feet, and this depth of water continues throughout the entire distance. The highest water-mark was 20 feet above the stage of water at the time of this examination. The current of the river is hardly perceptible at low water, though very rapid at high. About a mile below the mouth, in a bend of the gorge, is a cut sand-bar from 18 to 20 feet high.

The walls are 53 feet apart at the narrowest point. The rock is sandstone, of good quality, stratified; dip of the strata is about 40°, inclining down stream.

The rocks continue for some miles below Kilbourn City, though they do not present the same uniform appearance as above, the river widens, and sand-bars and low banks again appear. From this point to Portage the river is filled with sand-bars, and very wide, and running through low, rolling prairie-land, thinly wooded in many places; islands and sloughs are very numerous.

The first sand-bar in the river is about a mile below the first sand-bank. Below this the bars become more and more numerous, until just below Slab Slough they seriously impede the passage of lumber. The sand from the bars and from the banks is of the same character as the specimens accompanying this report show, making it manifest that the bars owe their formation solely to the wash of the banks.

The sand is fine, clean, and free from all vegetable matter. It is composed of silex, mixed with garnet, carnelian, and notable quantities of iron, which may be readily detected by a magnet. Several experiments made upon the sand from different parts of the river give the following ratios of iron contained: From bank No. 3, being 1,000; sand from Dekorra gives 143; from a bar at Lone Rock, 313; from shore at Lone Rock, 310, showing that the sand in moving down the river loses most of the heavier iron particles.

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The average specific quantity of the sand is 1,396; a cubic foot of water weighing 62.4 pounds, a cubic foot of sand will weigh 87.1, a difference of 24.7 pounds.

Respectfully submitted.

JOHN PIERPONT,
Assistant Engineer.

JOHN NADER,
Assistant United States Engineer,
In charge Wisconsin River Improvement.

PORTAGE CITY, *December* 9, 1871.

A 22.

IMPROVEMENT OF DU LUTH HARBOR, MINNESOTA.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 12, 1872.

SIR: In answer to the resolution of the Senate of the 9th instant, "That the Secretary of War be directed to communicate to the Senate such information as may be in the possession of the War Department respecting the canal and dike at Du Luth, Minnesota, and their effect upon the harbor of Superior, Wisconsin," I beg leave to transmit copies of the correspondence of this office in relation to the matter in question, with explanatory maps.

The action of this office, together with its conclusions and professional opinions in the premises, as well as those of its agents, will perhaps be best understood from the following statement:

A communication was received at this office September 13, 1870, from Hon. C. C. Washburn, calling attention to a canal which was being cut across Minnesota Point, near the harbor of Superior, Wisconsin, which, if completed, would, in his opinion, ruin the entrance to that harbor, and requesting that immediate measures be taken to restrain the parties from doing further damage. This communication was transmitted to the Secretary of War September 20, 1870, with a letter from this office inviting his attention to its contents, and stating that the improvement in question was carried on by private enterprise, and was intended by its projectors to comprise an outer breakwater and an inclosed basin between Rice's Point and Minnesota Point, with a cut through the latter to connect this basin with the waters of Lake Superior, having its exit protected by the breakwater. The project contemplated the completion of the basin before the construction of the canal. But that it appeared from General Washburn's letter that the cut across Minnesota Point was being made before completing the bulk-head or dike to inclose the basin. That, if so, the prosecution of the work upon the cut should be immediately stopped, because a canal made across Minnesota Point, allowing the waters of the river and bay of Saint Louis to flow freely into Lake Superior, would prove seriously detrimental to the navigable entrance now being improved by the United States; and it was therefore suggested that the United States district attorney for that locality be instructed to prevent the cutting of the canal until the basin was inclosed.

March 28, 1871.—Information having been received at this office that work upon the Du Luth Canal had been or was about to be resumed, a copy of the above letter of September 20, 1870, was transmitted to Major Houston, Corps of Engineers, in charge of the harbor-improvements at Superior City, with directions to report promptly any attempt to resume

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work upon the canal. A copy of the same letter and of these instructions to Major Houston were transmitted at the same time to Senator Howe, of Wisconsin, for his information.

April 24, 1871.—A copy of instructions from the Department of Justice to C. K. Davis, esq., United States attorney at Saint Paul, Minnesota, dated April 20, 1871, to "institute such proceedings by injunction or otherwise as will stop the cutting of the canal," was received at this office.

May 1.—Major Houston reported that dredging was resumed on the canal across Minnesota Point on the 24th April.

May 3.—This reply was submitted to the Secretary of War with the suggestion that it be referred to the Attorney-General for such action as might be deemed necessary.

May 6, 1871.—Major Houston forwarded information, received from the foreman of the harbor-works at Superior City, to the effect that the canal, April 30, was between 30 and 40 feet wide, and 5 feet deep; that a small steamer, drawing 4 feet, had passed through on that day, and that enough of the practical effect of the canal can now be seen to verify the opinion that, unless a dike is constructed between Minnesota and Rice's Points, the flow of water through the artificial channel must of necessity seriously weaken the current passing out at the natural entrance. This communication was submitted to the Secretary of War, with the suggestion that the matter be referred to the Attorney-General. This information was also communicated to the district attorney at Saint Paul, by Major Houston.

May 22, 1871.—At the request of C. K. Davis, esq., United States district attorney, received through Hon. M. H. Carpenter, a copy of the report of the board of engineers convened January 5, 1870, to consider and report upon the plans submitted by Colonel Wheeler, Corps of Engineers, for the improvement of the harbor of Du Luth, was transmitted to the district attorney through the War Department.

Proceedings were had before Judge Miller, associate justice of the United States Supreme Court. In disposing of the temporary injunction, Judge Miller thus expresses himself:

> If, before the final hearing, it shall be made to appear in the manner indicated, or in any other manner satisfactory to the court, that the canal can be protected by a break water, so as to prevent the too rapid diversion of the water from the bay, or can, in any other manner, be completed without injury to the Government works, and if the complainants put their work in that condition, the injunction may be modified or dissolved. Nor can I doubt, if the defendants here should ask of the Department in charge of these improvements a careful inquiry into the plan which they believe essential to their interests, that some mode of prosecuting such improvement would be found which would meet the approval of that Department, and obviate the necessity of a final decision by the court.

June 6, 1871.—J. J. Egan, city attorney for Du Luth, wrote to this office that the canal had been finished at that time to a width of 50 feet and depth of about 8 feet; that crib-work had been made for 75 feet into the lake on the north side of the cut, with a large quantity of material on hand for its further extension; that the expense incurred to that time was upward of $50,000, but that no steps had been taken to complete the dike, although it was a part of the plan; that an injunction had been granted, at the instance of the United States, to prevent further construction of the canal until the dike was built; and that, under the present situation of the work, the city of Du Luth is in danger of losing the entire work already completed, as it cannot be protected.

Under these circumstances, he asks, in behalf of the city of Du Luth, that the injunction be dissolved and further proceedings stayed, upon

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the city executing a bond in the sum of $100,000, conditioned that the dike be completed, in a good and sufficient manner, before the 1st day of December, 1871, and be maintained in such condition; the city of Du Luth also agreeing to complete the canal across Minnesota Point in accordance with the plan specified in this letter, and at such time as the city may be able to do so; the specification of the plan being, the canal to be 150 feet wide, 16 feet deep, and protected on the sides by crib-work extending into Lake Superior into about 18 feet water, and the contemporaneous construction of a dike or dam across Superior Bay, between Rice's Point and Minnesota Point, with locks for entry and exit of such craft as navigate the bay.

June 7, 1871.—This communication was submitted from this office to the Secretary of War, with the recommendation that the injunction be dissolved on the proposed conditions, because, if carried out in good faith, everything desired in asking for the injunction would be accomplished.

June 7, 1871.—This communication of the city attorney of Du Luth was transmitted by the Secretary of War to the Department of Justice with the request that the district attorney of Minnesota be instructed to consent to the withdrawal of the injunction upon the conditions and according to the plan therein contained, and (June 8, 1871) the Attorney-General informed the Secretary of War that the district attorney had been instructed accordingly.

June 20, 1871.—The Secretary of War referred to this office a letter from Hon. M. H. Carpenter, of Wisconsin, objecting to the above arrangement upon the ground that such a bond would be wholly void by reason of want of authority to make it. To which answer was made by this office that, as to the validity of the bond, it was supposed, when the recommendation was made, that if the agreement was not carried out in good faith by the town, the United States court could compel a compliance with it.

June 21, 1871.—Governor Fairchild, of Wisconsin, telegraphed to the Secretary of War that the harbor of Superior was closed to the boats usually entering there because of the canal across Minnesota Point.

June 22, 1871.—Major Houston was directed by telegram to report at once the facts of the case, which he did as follows: "Lieutenant Miller telegraphs: 'Width of canal, 44 feet; depth, from 6 to 16 feet; velocity, variable, from four to six miles an hour; velocity at entry, about the same; depth at entry, 9 feet; water shoaler there than before canal was cut; boats that came in then cannot enter now; no apparent cause for shoaling, except canal.'"

This telegram was transmitted June 30, 1871, to the Secretary of War, with the remark that—1st. The depth at the entrance is the same that it was a year ago, as shown by Major Houston's map of June 17, 1870; that the velocity of the current through the entrance is from four to six miles an hour, the width at the entrance being 420 feet. 2d. That the canal is 44 feet wide, and 6 feet deep, (the least cross-section governs the discharge,) and the velocity of the current the same as through the natural entrance at Superior City.

Therefore, under such a state of facts it is impossible that the discharge through the canal could have any appreciable effect in diminishing the depth of the natural entrance at Superior City. The simple statement that the velocity of the current through the natural entrance at Superior City is from four to six miles an hour is sufficient to prove incontestably that no decrease of depth in the entrance has been caused by a reduction in the flow of water through it.

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It is also recommended in this communication to the Secretary of War that it be required of the city of Du Luth that it should neither widen nor deepen the canal until the dike is finished, and that the construction of the dike should commence before the close of July and be continued with all practicable dispatch until finished; the city, at the same time, to be allowed to secure the work already done from either filling in or widening. A copy of this communication was sent July 6, 1871, by the Department of Justice to the district attorney for Minnesota.

July 6, 1871.—A letter was received from J. J. Egan, esq., giving information concerning the condition of the canal across Minnesota Point and proposed works at the head of the bay, in which he mentions the sudden changes in the direction of the current through the canal: "Within fifteen minutes a current passing out into the lake will be transformed into a current running heavily into the bay from the lake," no heavy winds or other abnormal conditions existing. He also states that during all the time the canal has been opened the waters of Saint Louis River and Bay pass out of the entry in their usual quantity and velocity. The depth of water had increased at the entry to 9½ feet, and was constantly increasing.

The receipt of this communication was acknowledged July 8, 1871, with the remark that the causes of the changes of direction in the current through the canal-cut are to be looked for not only in the variations in the volume of the Saint Louis River, but in the oscillations of the surface of the lake due to variations in the direction and strength of the winds, and the variations of atmospheric pressure, &c.

July 8, 1871.—A report from Major Houston, received July 3, was transmitted to the Secretary of War. From this report and the accompanying drawings, it appeared that the diminution of depth reported to exist at the entrance was occasioned by the extension of the pier on the Minnesota side. The extension had crossed the entrance-channel and reached a shoal lying outside, which vessels entering had to cross. The inconvenience would be temporary, and was anticipated in the original design for this improvement, in which there is an estimate for dredging at this point when found necessary to prevent obstruction to navigation. The plan of improvement contemplates extending both piers beyond this shoal.

A copy of the report of Major Houston, and copies of the drawings accompanying it, were transmitted to the Department of Justice for the information of the district attorney at Saint Paul.

July 13, 1871.—The following letter was addressed to the Secretary of War, and a duplicate sent to Senator Carpenter:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., July 13, 1871.

SIR: In an interview just had with the Hon. M. H. Carpenter, he read to me a letter which he addressed to you on the 11th instant, concerning the removal of the injunction on the Du Luth Canal. He has fully explained to me his reasons for regarding the bond of the town of Du Luth void.

My reason for recommending the bond was that I thought the arrangement under which it was given would secure the construction of the dike during the present working season more effectually than any other arrangement; and I still think it would do so, if the bond were not void or voidable.

Senator Carpenter suggests that that end could have been attained by maintaining the injunction until the dike was built, but permitting the town of Du Luth to secure the work already done by building the necessary crib-work, the injunction to be dissolved upon the completion of the dike.

Had I been aware that the bond of the town of Du Luth was substantially no security; or that the suggestion in reference to it would be regarded as a positive instruc-

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tion to the United States district attorney, which he was not at liberty to modify, in his discretion, so as to secure the object sought; or that the removal of the injunction and the conditions of removal were not discretionary with the United States judge, I should have abstained from any other than a general recommendation that the court take such action and exact such security as it considered proper to attain the end sought; that is, the construction of the dike during the present year.

I do not know whether the injunction has been dissolved. If it has not been, and the suggestion as to its modification instead of its removal receives your approval, there may be time to communicate them to the court before its action.

I have no reason to question the good faith of the town of Du Luth, or of its agent, in accepting the proposition to build the dike this year, and to give sufficient security to insure its construction; nor have I, therefore, any reason to suppose that objection will be made by them to the substitution of a modified injunction instead of its withdrawal under the bond of the city. Should, however, the action of the court have been already taken, personal securities upon the bond may still be exacted. It has not yet been received at the War Department.

There is an additional security for the construction of the dike, namely, the withholding by Congress of appropriations for the breakwater at Du Luth until the dike is built.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

July 14, 1871.—J. J. Egan, attorney for the city of Du Luth, was requested to submit a plan and mode of construction of the proposed dike from Rice's to Minnesota Point, at the earliest day practicable, for the approval of the Secretary of War, and that the project should provide for inspection of the work by officers of the Engineer Department during and after construction, so as to insure adherence to it; and on the same day Major Houston was also instructed to submit a plan, with estimates of cost, for such a dike, as well as the best location for it, so as to prevent the waters of the bay and river passing into the lake through the Du Luth Canal.

August 11, 1871.—The Secretary of War referred to this office a letter from George W. Perry, of Superior, Wisconsin, to Hon. M. H. Carpenter, in reference to the effect of the Du Luth Canal upon the depth of water in the channel of the entrance to the bay of Superior. This letter was referred (August 12) to Major Houston, with directions to inquire into and report upon the statements therein contained, especially that in three days the Superior channel had filled in 2 feet 4 inches, no storm having occurred during the time. He was also directed to ascertain by whom and in what manner the depths in the channel were measured. This was returned by Major Houston, August 28, 1871, with a report from Lieutenant A. M. Miller, Corps of Engineers, from which it appeared that the channel had a depth of 8½ to 9 feet, and that the information upon which Mr. Perry based his communication was very unreliable. In Major Houston's opinion, it was not possible that the effects of the canal could have been the cause of any such sudden change.

August 12, 1871.—Major Houston, in compliance with the instructions of 14th July, submitted a plan of a dike across the head of Superior. His attention was called to his omission of its location, and he was further instructed (August 17) to submit a plan for such a location for the dike as would be most suitable for the commerce of Du Luth, both exteriorly and interiorly, and at the same time an estimate of its cost.

August 30, 1871.—In a report received this day, Major Houston supplies the above omission. His estimated cost of the dike is $34,098. He states: "If the dike is not imperatively needed, it would be better not to put it in, and I feel very doubtful of its necessity after the ex-

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tension of the pier at Superior entry into deep water." And further: "The observations on currents at the entry, canal, and mouth of Saint Louis River, show that at the present stage of water in the Saint Louis River the canal has no detrimental effect on the entry."

August 22, 1871.—The Secretary of War refers to this office a communication from the Department of Justice, inclosing certain exceptions made by Hon. M. H. Carpenter, in reference to the bond of the city of Du Luth, suggesting that specifications should be obtained from this office showing the kind, form, and dimensions of the dike across the bay of Superior, as agreed upon, to be inserted in such bond. To this it was replied, August 25, 1871, that the attorney for the city of Du Luth had been requested to furnish a plan of the dike the city proposed to build, but that it had not yet been received; that it would not be judicious to require the city to build the dike in the manner proposed in the plan submitted by Major Houston, since some other method of construction might be more useful for their purposes and equally effective for those of the United States. It was recommended, therefore, that the bond specify merely that the dike shall be built in a substantial manner and to the satisfaction of the Secretary of War, and be completed not later than 1st of December next, (1871.) This reply was sent by the War Department to the Attorney-General August 26, 1871.

September 2, 1871.—The city attorney of Du Luth transmitted a plan for the dike across Superior Bay. In acknowledging its receipt he was informed, September 9, 1871, that the plan submitted should be modified to give permanency to the structure by strengthening the piling by an earth filling; that it should be made a continuous structure from shore to shore, and not left with any opening whatever. If a passage-way through the dike is necessary, this must be made in the form of a lock; and respecting the site of the dike, the local authorities must make their own selection, subject to the decision of such tribunals as may have authority to decide in any conflict of interests that may arise. The object sought to be attained by the War Department in requiring its construction is the permanent maintenance of the same volume of discharge at all seasons of the year through the natural entrance that existed before the canal was cut through Minnesota Point.

October 27, 1871.—Major Houston was instructed to make, just before the close of the working season, a thorough and full inspection and examination of the works of improvement at Superior City Harbor, and also of the cut made through Minnesota Point and the dike which was being built in connection therewith. With the results of this examination he was directed to give his views upon the question of the improvement of Superior City Harbor and of the harbor of Du Luth.

November 14, 1871.—Application was made by the city attorney of Du Luth in behalf of the city council for an extension of the stipulated time of completion of the dike across Superior Bay to April 1, 1872, giving an account of the progress of the work and the causes which had retarded its progress, although every effort had been made to have the work completed within the specified time. This was transmitted to the Secretary of War with the following indorsement:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., November 24, 1871.

Respectfully submitted to the honorable Secretary of War.

The object to be attained by the construction of this dike is to prevent the waters from Saint Louis River from flowing through the canal made by the city of Du Luth across Minnesota Point, instead of through the natural outlet at Superior City, and as the scouring or deepening of the bar at the Superior City entry is greatest during the

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season of freshets, or high water in the streams flowing into the bay of Superior, it is believed that if the dike is thoroughly completed by the commencement of the season of spring freshets, no damage will result to the works of the United States at the entrance to the harbor of Superior City, nor will the depth of the water on the bar be diminished in consequence of the non-completion of the dike on the day named in the bond, *i. e.*, December 1, 1871.

For these reasons, together with the statement within, "that every effort has been made to have the work completed within the time specified," I would recommend that the period be extended to March 15, 1872, which is substantially in accordance with the request of the authorities of the city of Du Luth.

Should the recommendation meet the approval of the Secretary of War, it is suggested that a copy of the communication be furnished the district attorney for Minnesota through the Department of Justice.

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

The extension of time was approved by the Secretary of War, December 5, 1871, and a copy of the application and its indorsement transmitted to the district attorney at Saint Paul through the Department of Justice.

November 22, 1871.—Major Houston transmitted a record of simultaneous observations, showing the direction and velocity of the currents and the tide-gauge readings at the entry of Superior Bay, at the Du Luth Canal, and at the mouth of the Saint Louis River, on the 9th, 10th, 11th, and 12th of August, 1871, with the state of the barometer and the direction and velocity of the wind. He gives it as his opinion that, so far as these observations bear upon the question of the Du Luth Canal, its effect upon the entry, and the necessity of a dike to prevent the waters of the Saint Louis River from passing through the canal, thus diminishing the scouring effect necessary to maintain the proper depth of water at the entry, they seem to show that, except in times of high water in the Saint Louis River, sufficient to overcome the lake influence, the canal would have no effect whatever on the entry, as the current both through it and the entry is dependent entirely upon the rise and fall of the lake. But in times of freshets he thinks that the canal will, judging from the relative cross-sections of the canal and entry, and their relative distances from the mouth of the Saint Louis River, take enough water from the entry to reduce the flow through it perhaps two-fifths. He also reported the work on the dike as very poorly executed; that it was badly out of alignment, not water-tight, in some parts badly broken, and in others entirely gone. The manner of building is not in accordance with the agreement entered into with the city of Du Luth.

November 29, 1871.—The Secretary of War referred to this office a memorial of W. R. Smith and others, of Superior City, in relation to the injury done to the harbor at that place by the cutting of the canal through Minnesota Point by the city of Du Luth, and asking to have the legal proceedings revived, to the end that further work on the canal may be perpetually restrained, and the canal closed.

December 7, 1871.—This was returned to the Secretary of War with a letter to the effect that there was nothing in this memorial to modify in any way the recommendations heretofore made from this office upon this subject. The statement of the memorial that the entrance to Superior Bay has shoaled is shown to be unfounded by the reports of Major Houston.

December 20, 1871.—A letter was addressed to J. J. Egan, esq., city attorney of Du Luth, in reference to the manner of building and the condition of the dike across Superior Bay as not in accordance with the agreement entered into, and informing him that instructions had been

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given to have the dike inspected monthly, and that unless these inspections show a more satisfactory condition of the dike, and give assurance that it will be completed in a substantial manner by the middle of March, 1872, such proceedings will be had as will secure the entrance against injury.

February 7, 1872.—The Secretary of War referred to this office for report a communication from Hon. J. M. Rusk, inclosing a letter from Governor C. C. Washburn, of Wisconsin, in regard to the dike at Du Luth, objecting to its location, and claiming that the canal should be closed unless a close dike is built from near the east side of the canal to Rice's Point, or that it be constructed with gates, if placed where now contemplated by the city of Du Luth. This communication was returned February 13 to the War Department, inviting attention to the letter to the city attorney of Du Luth of September 9, showing that this office has uniformly abstained from giving any decision in regard either to the location or plan of constructing the dike, the only point insisted upon being that it shall be so located and constructed as to exclude from the Du Luth Canal, at all seasons of the year, the volume of discharge of the Saint Louis River, and also the reservoir-flow of Superior Bay and its connections, excepting such part of that bay above the southern extremity of Rice's Point known as the harbor of Du Luth.

March 7, 1872.—The secretary of state of Minnesota transmitted to the War Department certified copies of a memorial of the legislature of Minnesota to the Secretary of War, urging that no hasty or *ex parte* action be taken to thwart the construction of the Du Luth Canal, or the dike across Superior Bay.

March 15, 1872.—Telegram sent to Major Houston to make a personal inspection of the dike at Superior Bay, and report its condition, as it had been formally reported to the Secretary of War by the mayor of Du Luth that it was completed in every respect.

March 25, 1872.—Major Houston was directed to inform this office whether any freshet had occurred in the Saint Louis River since the Du Luth Canal was opened; and, if not, whether any material rise in the river had occurred since that time, and what had been its greatest volume of discharge since the opening of the canal as compared with its discharge in freshets. To which he replied, March 27, that as far as his own observation extended there had been no freshet since the opening of the canal, but that he is credibly informed that at the time the canal was first opened the water-surface in the bay of Superior was, at that point, 8 inches higher than the lake. That no observations had been made to ascertain the discharge of the Saint Louis River in time of freshets, but that such would be, as soon as the season permitted. He stated further that all observations on the current at the canal entry and at the mouth of the Saint Louis River from June last to the present time show a continual ebb and flow of the current. And also that the least depth of water in the channel over the present bar is essentially the same that it was in March, 1870.

March 25, 1872.—A report was received at this office from Major Houston of his personal inspection of the dike at Superior City, in obedience to the instructions of March 15. He states:

The dike extends from near the southern extremity of Rice's Point to Minnesota Point, and is 4,490 feet in length. It is constructed of crib-work weighted down by stone ballast and filled with sand. The width of the dike is 10 feet. With the exception of about 800 feet at the eastern end it is constructed of sawed timber, mostly 6 by 8 inches, and 4 by 8 inches, so that the side walls are 8 inches thick, and are connected throughout by ties of the same material, and secured by wrought-iron spikes. For 800 feet near Minnesota Point, the work is constructed of round logs secured by

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iron bolts. The side walls are lined on the inside with inch boards closely jointed to hold the filling. The dike is not built in separate cribs, but is continuous throughout, the timbers of the side walls breaking joints, with the exception of a section of 100 feet, at the end of the log crib-work. This portion is a single crib, and fits close to the rest of the work. In case it should ever be necessary to make an opening in the dike, this section can be removed without disturbing the rest of the work. The filling of sand was obtained from Rice's Point, and conveyed by railroad-cars, a track having been laid over the whole length of the dike for the purpose. The work has, therefore, been well settled by the continual passage over it of a locomotive and train.

Owing to the uneven character of the bottom, and the presence of soft material, the work has settled unevenly, so that at some points it is only six or eight inches above the water-level, and at others 2 or 3 feet. A force is engaged leveling up the low places.

The filling is generally up to the top of the work, except at two or three points where it seems to have settled. The work, as far as I could judge, is substantially built for the locality, which is not exposed, and is at present an effectual barrier to any current. It cannot, however, be pronounced complete according to the requirements of the Government, as the water is now at its lowest stage.

The bay and river are entirely frozen over, as is also Lake Superior, for several miles east of Du Luth, and it is not probable that the ice will break up for some weeks. The weather is exceedingly cold. Last season both the bay and lake were open at this date.

As an exception to the above statement, the canal, through Minnesota Point, is not frozen over, and has not been during the winter for any length of time. The current has continued to ebb and flow in the same manner as observed last season. It is possible that, after the ice goes out, portions of the dike may settle, and the filling work down, but this can easily be remedied by building up to the proper height, and continuing the filling as long as any settlement takes place.

I would respectfully recommend that the dike be raised until it shall be in no place less than 3 feet above the present water-level; that the filling be continued as long as any settlement is observed, and that the ends of the dike be connected by earthen embankments with the high ground at each end, the top of the embankment to be 10 feet wide, and of the same height above water as the dike.

In conclusion, I would say that all possible requirements have been fulfilled thus far, and the work accomplished has been a marvel of industry and enterprise, affording the most complete evidence of the good faith of the city of Du Luth in this work.

The work cannot be pronounced as complete until after the ice has disappeared, and the effect of the spring freshets observed.

March 29, 1872.—Major Houston submits a report upon the memorial to Congress from the State of Wisconsin, dated March 2, 1872, asking for proper enactments for filling up the canal at Du Luth, and for removing the dike to the bay of Superior. This memorial was transmitted to the Secretary of War by the chairman of the Senate Committee on Commerce for such information as he might be able to furnish, together with recommendations and suggestions, and was by the Secretary of War referred to this office, March 23, for report thereon.

Major Houston gives an account of the harbor-improvement at the head of Lake Superior, and concludes that the canal has had no detrimental influence upon the entry of bay Superior; that it can have no injurious effect except in time of freshets; that this injurious effect will not last after the works of improvement at the entry are completed and a channel excavated either by the scour of the current or by dredging; that all possible diminution of scour will be prevented by the dike if properly built, and that, after the completion of the United States improvement at the Superior entry, probably this season and certainly the next, there will be, in his opinion, no further necessity for the dike for the purposes for which it was built.

Most of the views expressed by Major Houston in this report are concurred in, but some of them are not; as in the judgment of this office a dike to exclude the flow of the Saint Louis River through the Du Luth Canal during floods will be as necessary after the completion of the harbor-works at Superior entrance as before their completion.

April 6, 1872.—A letter from W. B. Gaw, civil engineer, to the Secre-

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tary of War, of March 9, 1872, reporting, at the request of the authorities at Du Luth, the condition of the dike across Superior Bay, was returned to the Secretary of War, with a copy of Major Houston's report of March 25, and the following remarks: "It will be seen that Major Houston is of the opinion that the dike cannot be pronounced complete until after the ice has disappeared and the effects of the spring freshets observed. He recommends that the dike be raised until it shall be in no place less than 3 feet above the present water-level; that the filling be continued as long as any settlement is observed, and that the ends of the dike be connected by earthen embankments with the high ground at each end; the top of the embankment to be 10 feet wide, and of the same height above water as the dike."

These views were concurred in, and it was suggested that a copy of this letter and of Colonel Houston's report be sent to the mayor of Du Luth for his information and guidance.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

CHICAGO HARBOR, ILLINOIS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., November 22, 1871.

SIR: I transmit herewith a letter just received at this office from the president of the Illinois Central Railroad Company, asking that instructions be given the United States district attorney to relieve that company from the injunction now in force at the instance of the Secretary of War, so as to enable it to commence the construction of docks in the outer harbor at Chicago north of Randolph street.

Though no specific declaration has been made in behalf of the railroad company of its acceptance of the limiting harbor or dock lines proposed by the board of engineers convened in Chicago in September last, (a copy of the report of the board, with your approval of its report and plan, was sent to the president of the company October 7,) it is inferred that the company intend to conform to the approved plans of the War Department in building their docks.

In the printed statement in relation to docks and wharves in the outer harbor of Chicago, submitted by the president of the Illinois Central Railroad Company to the Secretary of War, July 25, 1871, the following language occurs, viz: "How far these docks shall extend out into the harbor is a question which it [the company] is desirous to have settled. In this respect the company has no plan which may not be modified, and which will not be cheerfully and immediately modified to correspond with what the Government officers may deem the interests of commerce."

I beg leave to suggest that the United States district attorney be instructed from the Department of Justice to withdraw the injunction issued at the instance of the Secretary of War, restraining the Illinois Central Railroad Company from proceeding with the construction of docks in the outer harbor of Chicago, upon the condition that the said company shall agree, in such form as the district attorney may consider

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best, to conform to the approved plans and limiting harbor-lines of War Department in the construction of said docks.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineer

Hon. W. W. BELKNAP,
Secretary of War.

A 23.

UNITED STATES ENGINEER OFFICE,
Chicago, November 29, 187

GENERAL: I have the honor to submit, for your approval, a modi cross-section for the breakwater at this harbor.

I inclose a report by Assistant W. H. Hearding, on the subject stone foundations for crib-piers, which fully sets forth the reasons wl have led me to propose this modification.

In the cross-section given, the depth of water is taken at 22 fe inches more than the average.

The ultimate plan I propose is a stone breakwater, composed be the water-level of loose stone, and above of masonry. The first su structure should be of crib-work, as now built, filled with loose st By the time this crib-work is decayed the foundation will have bec permanent, and the work can be leveled off preparatory to putting the permanent superstructure.

The cross-section which I have given shows the maximum amoun stone required for the foundation, equal for a length of 50 feet of br water to 436½ cords, which would give for the cost, at $6 per cord, price now paid for crib-filling, $2,619. The cost of a crib 50 feet long 30 feet wide and 18 feet high is $3,140.39, to which amount should added the varying expense of putting on the superstructure, due to unequal settlement, tilting, and shifting of cribs. It is probable t the stone can be procured for $5 or $5.50 per cord for the foundation there will be less delay and handling than in filling cribs.

At least 100 cords more than the amount given above could be ad to each 50 feet of the breakwater without increasing the present cos the work. The immediate benefit of the work will be greater than if present plan is carried out, and at a less cost. The dotted lines sh the cross-section to be given to the work when the stone is first thru in. This will give protection to vessels lying in the "basin." The ef of the waves will be to flatten out the slope on the seaward side, an carry the stones on the crest over to the inner slope. Stone will t be added until the foundation has become sufficiently permanent for crib-superstructure.

It is proposed to make the cribs for this part of the work 18 feet w and 200 feet long. The stone will be leveled off so as to be 4 feet bel the water-level before placing the cribs.

The first cost of the work, with the cross-section shown by the dot lines, will be $40 per running foot. The cost per running foot of breakwater complete, according to the section, is $75. The cost running foot of the breakwater, as now built, under the supposition t the cribs do not move from the position given them, for the same de of water, is $103. This saving is due to the diminished width of superstructure, and to the cheapness of stone in this locality.

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The cross-section of the foundation can, therefore, be very much increased without increasing the cost of the work, and a much more durable and satisfactory result will be obtained.

Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

STONE FOUNDATIONS FOR CRIB-PIERS.

Of the materials which are used in the construction of works for the improvement of harbors, stone is the principal constituent; first, by reason of the facility with which it can be obtained; and secondly, on account of its being the cheapest material, whose solidity and specific gravity are adequate to resist the force impelled by waves, or through the collisions to which it is constantly subjected at all points where commerce is conducted by means of steamers and sailing-vessels, and for the particular benefit of which the improvements at the mouths of rivers, by the construction of protection-piers, are usually made. The magnitude of such works is generally so extensive that, however cheaply this material can be procured, its economical use is carefully studied, and in order to effect a work of this character with as small an outlay as is practically consistent with the nature of the proposed improvement, as well as to adjust such artificial works in consonance with the physical character of the site to be improved, the material is placed in large boxes, or "cribs," as they are termed, which are framed of timber for this purpose, and by means of these are kept in a compact, symmetrical form.

If it were not necessary to practice an economical use of means in the conduct of the various kinds of artificial aids to nature, material changes would undoubtedly be made in the methods adopted for their construction, as, in the case of pier-work, there is no doubt as to the superiority of cut-stone masonry over the use of rough fragmentary stone, incased in timber for such purpose; it is, therefore, the difference in the cost of the methods which partially determines the one to be adopted. The writer of this article is, however, of the opinion that stone, either natural or artificial, well bonded with cement, is the only proper material to use for piers in themselves, built upon proper foundations; but where an immediate improvement is urgent, and a strictly economical use of the means, which are available for such purpose, is necessary to be observed, as before stated, the reasons for incasing the stone in cribs for protection-piers to channels are obvious to any engineer of experience; for, as is well understood, at the outlets of rivers it is desirable to confine the river-current within the limits of as narrow a channel as is consistent with the requirements of navigation, in order that the scouring effect of the river-current may be maintained beyond the extremities of the piers to free the channel from sedimentary deposit. If the piers should be constructed of rough-quarried stone thrown in loosely on either side of the channel, the natural slope which the stone would assume thus deposited in water of sufficient depth for the purpose of navigation, might be a serious obstruction to the channel, and if the width between the piers should be increased to meet this difficulty, the scouring effect of the river-current would be diminished, while the volume of wave admitted during the prevalence of storms would be increased. The prejudicial effect from this latter cause is particularly marked where piers are constructed in continuation of the alignment of the outer reach of a river, which often forms an important portion of a harbor. Also, if the piers upon an exposed coast should be thus formed of stone of small size, they would be carried into the channel by the force of the seas, and form an obstruction; or if the adjacent beach should be of sand, and the piers formed by throwing in blocks of stone of a size sufficient to resist the force of the waves, the extraneous sand swept from the shores by littoral currents would be admitted into the channel through the interstices between the blocks and thus form an obstruction. In order, therefore, to effect an improvement of this character to meet the requirements at a medium cost, the system of incasing loose stone ballast in timber cribs has been adopted in constructing piers built to withstand the force of heavy seas, and in localities where they are not subjected to collisions by vessels, the strength of such cribs properly framed and bolted is adequate to the duty required in fresh-water seas.

The cribs which are used by the officers of the United States Engineer Department for the improvement of lake-harbors are built with tight sides and ends, the timbers being 12 inches square, carefully framed and firmly bolted together, with an open gril-

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lage-work for the bottom, the apertures between the timbers forming this grillage being large enough to admit of the free passage of the stone ballast. Opportunity is taken in fair weather to tow the cribs to the positions they are to occupy in the piers, and secure them in their respective places. When a crib has been thus conducted to its position and secured, a flooring of stout plank is laid over the upper center cross-ties, and a sufficiency of ballast is placed thereon to sink it to its bearings, after which it is filled as rapidly as possible.

Care is taken to throw in stone of small size for the filling of the first or lower portion of the crib, which can run through the grillage. If the bed is soft, or of a loose character, quite a large percentage will be forced through the grillage by the superincumbent weight of stone. The upper portion of the crib is filled with stone of the largest size. On a moderately firm bed the artificial assistance thus rendered has been found sufficient to sustain the cribs in their proper positions, but where the natural bed is composed of loose, shifting sand, further assistance has been found necessary to prevent them from tilting, through the effect of the action of the sea upon the lake-bed. This detrimental effect first led to a discussion of the subject.

It may be thought at the outset that, so long as the cribs forming a pier are not moved bodily, and do not actually dip so seriously as to endanger their tilting over, the utility of the pier is not impaired, upon the supposition that cribs thus tilted present the same impediment to the admittance of extraneous sand by preventing its percolation into the channel, just as they would if they remained in a proper vertical position. But if this result is not to be anticipated, there are good and sufficient reasons for using every effort to prevent their derangement.

There is always more or less subsidence to cribs which are set upon shifting foundations, and, for this reason, it has been customary to construct the cribs with the side timbers projecting beyond the ends of a crib proper. The projections or horns have been usually extended 2 feet beyond the end timbers. The intervals between the cribs inclosed by the projecting timbers have been, therefore, 4 feet in width when the extensions have been in perfect conjunction, but through the subsidence of the cribs imperfect junctures are often produced, which increase the width of the intervals, leaving an open space through which sediment in suspension can be introduced to the channel.

Fascines of brush, or slabs, are tightly packed in the intervals and ballasted with stone to prevent the introduction of extraneous matter. The horns or projections are, however, a source of weakness, as they are easily fractured by collision, and for this reason other means should be adopted, which would be equally effective, for the purpose required, without impairing the strength of the general structure.

But, to return to the subject of disarrangements or displacements: It being conceded that the stability and efficiency of piers depend upon the foundations upon which the cribs are set, this discussion hinges upon the best and cheapest method to be adopted for securing proper artificial foundations for cribs in loose soils.

In localities where the sand is of great depth, piles should be driven until the clay or rock bed is reached, and the spaces between them filled with stone of small size; but the cost of this method is so great as to have heretofore excluded its practice in ordinary works of the character described. Where the overlying sand is but a few feet in thickness, it should be removed until the clay or rock bed is laid bare for the reception of the cribs. If a trench is dredged to a depth of 3 or 4 feet below the natural level of the lake-bed for their reception, the tilting will be diminished. If a dredging-machine cannot conveniently be obtained for the purpose, the next best method, (perhaps the best under any circumstances,) is to form a foundation of round bowlder-stone of medium size, to a depth of 3 or 4 feet, upon the pier-alignment, to the full width of the pier, the surface of which should be made as level as practicable.

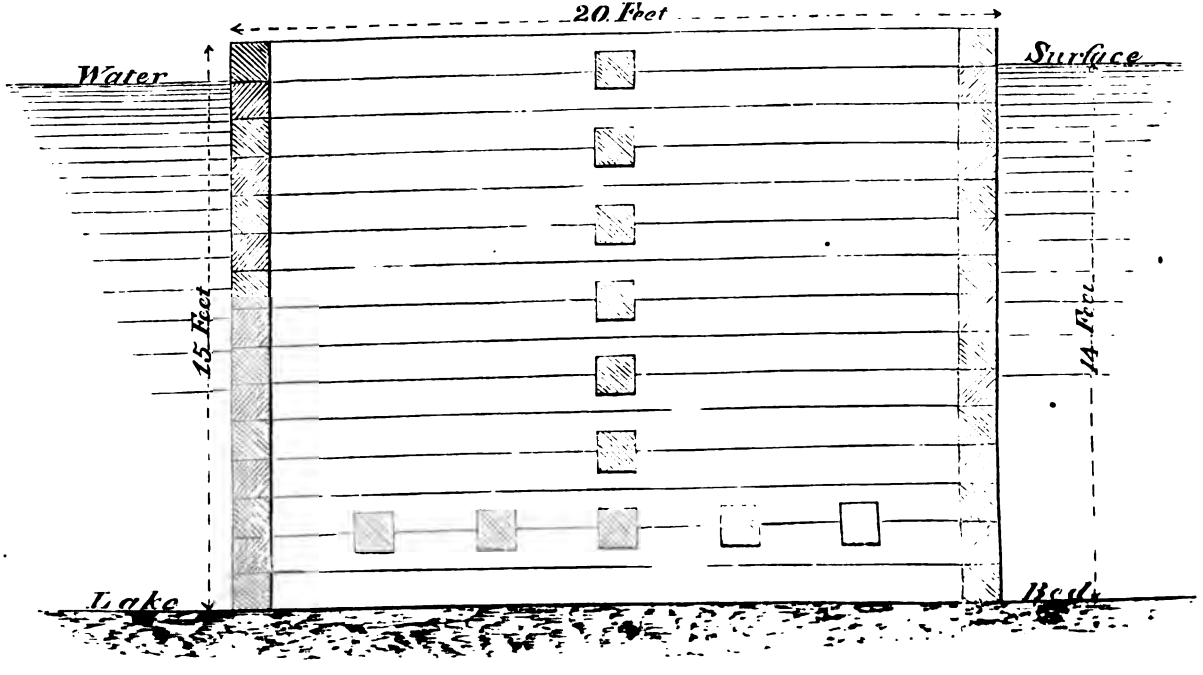
Flat quarried stones should not be used for this purpose, as they are usually of a lighter character than bowlders, and are more easily removed by the water, when agitated; besides which they will not conform to as perfect a level by the pressure of the cribs. Bowlders are also preferable to quarried stone for crib-ballast.

The action of the waves and the currents, induced by storms and other causes, cuts the sand from beneath the cribs and effects their subsidence, and during the process of constructing a work of this kind, the undermining effect will be particularly noticeable at the extremities of piers as each crib is set and subjected to the action of these forces. From these facts it is inferred that a combination of methods should be adopted, namely, by using loose stone for a foundation and confining the upper portion of the stone in well-framed cribs. As a preventive to the cutting out of sand at the base of the cribs, a distribution of stone along their sides has been effectively practiced; they have been usually thrown into a height of 3 or 4 feet, forming an apron to receive the shock of the waves, which are deflected downward upon their concussion with the vertical sides of the cribs; the cushion or apron thus formed prevents the water from washing out the sand at the angle formed by the crib and the lake-bed.

As the stone used in the formation of the foundation would necessarily extend outside of the cribs, the additional quantity required to form the apron would not be as

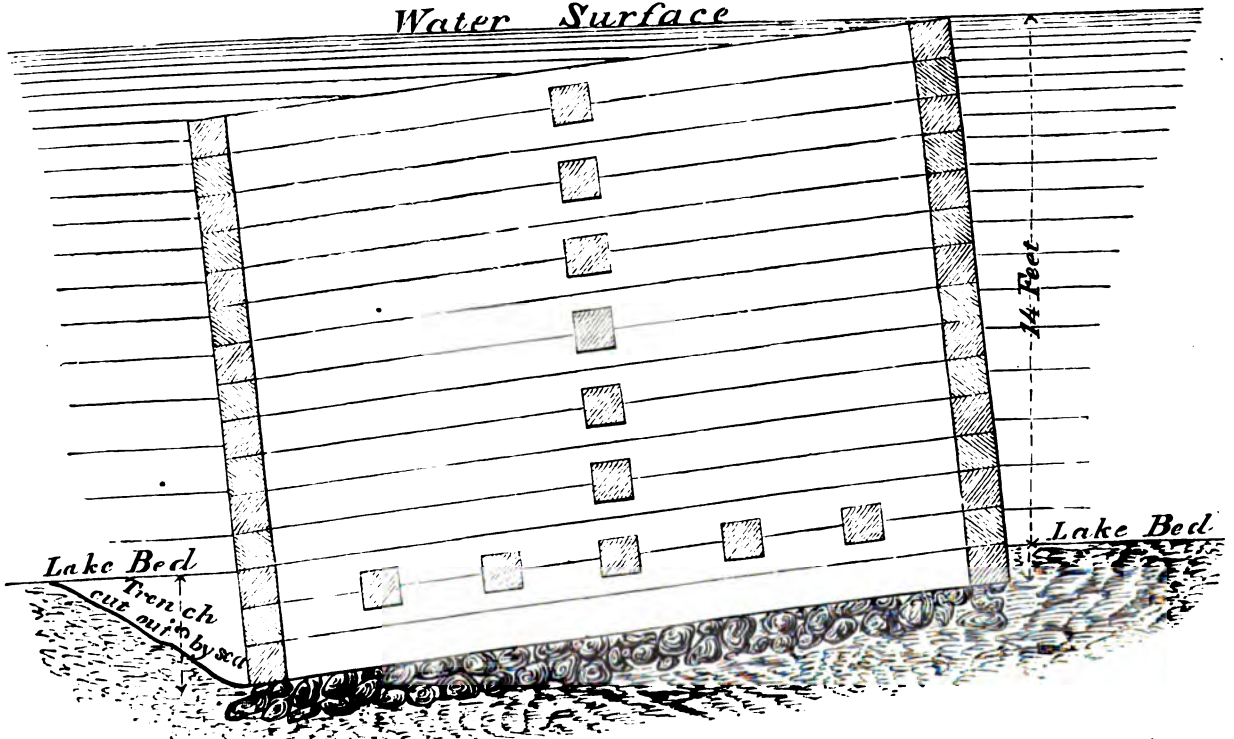
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Fig. 1.



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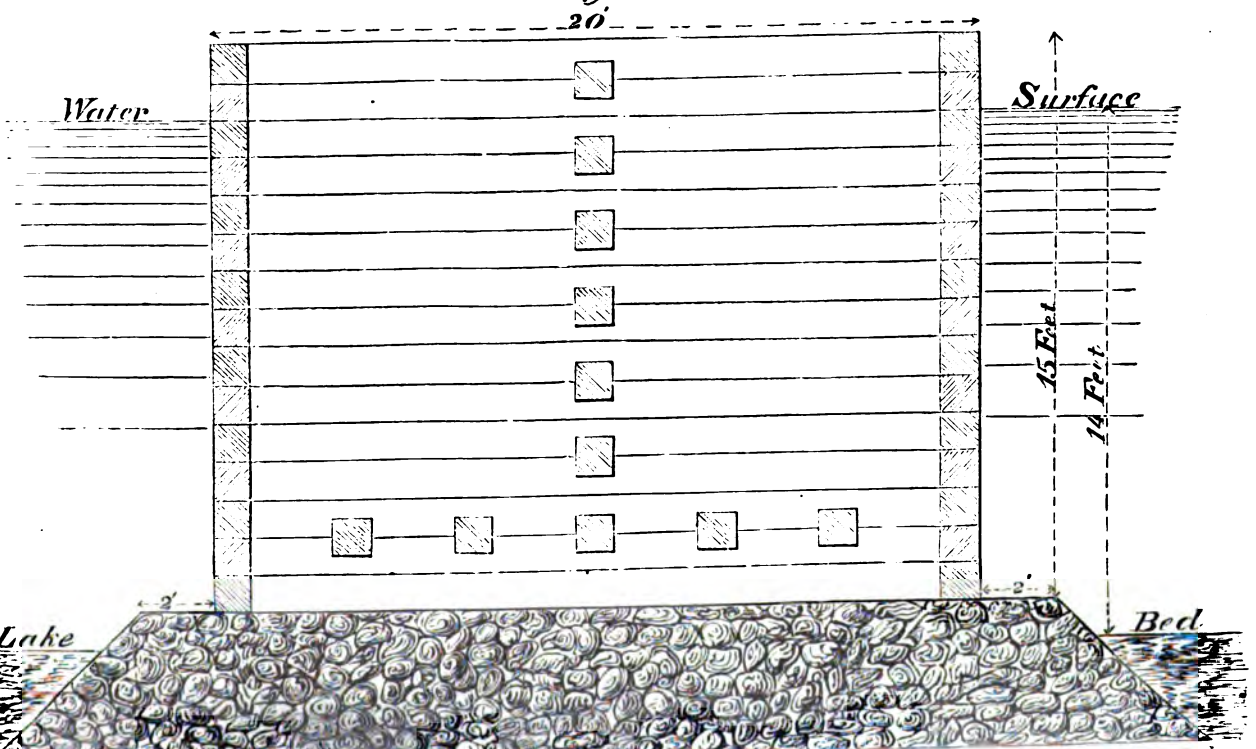
Fig 2



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Fig. 3



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large as that required to protect cribs sunk upon the natural bed; they would not however, spread to such a distance from the channel-side of the pier as to be an obstruction to navigation.

A clearer understanding of the subject will perhaps be derived through the following illustrations, the first of which exhibits the end view of a crib set horizontally upon a natural sand-bed in a depth of 14 feet of water. The width of the crib is 20 feet; the height is represented as being 15 feet. It is shown in a proper position before having been subjected to the action of the water.

Fig. 2 is not an exaggerated exhibition of the same crib after having been subjected to the action of the water. Many instances are known of cribs having settled much more seriously.

In this representation it is shown that a portion of the sand-bed has been washed from under the crib, and that the stone filling has settled down with it, and run through the grillage; but in the discussion of the relative cost of cribs, sunk with and without artificial foundations, the quantity of stone which may have actually run into the sand below the crib will not be estimated for a greater depth than is shown by the sketch, nor will the detrimental effect produced by the distorted position of the crib, nor the imperfect construction involved through the necessary insertion of wedge-shaped timbers to provide a proper bearing for the superstructure, be taken into the account of dollars and cents.

Fig. 2 represents the stone as having settled into the sand below the natural bed, on the outer or seaward side, to a depth of 4 feet, and on the inner or channel side, to a depth of 2 feet. It also shows the crib itself as having settled 3 feet on the outer, and 1 foot on the inner sides.

The quantity, therefore, contained in the prism of stone which has subsided below the natural bed, for a crib of dimensions 32 by 20 feet, approximates 32 by 20 by 3 feet = 1,920 cubic feet, or 15 cords, and the mean subsidence of the crib equals 2 feet, or two courses of timbers 12 by 12 inches square.

Two middle courses of a crib of the above dimensions contain, as per bill of materials used, 276 linear feet of framed timber, and 346 pounds of iron bolts. The average cost of these materials, with the framing, would be approximately as follows, the prices being taken from the contracts awarded by the Government in 1871, viz:

For 15 cords of stone ballast, at $8.25	$123 75
For 276 linear feet of framed timber, at 31 cents	85 56
For 346 pounds of iron bolts, at 4 cents	13 84
Total cost involved by subsidence of crib	223 15

Fig. 3 represents the same crib as being set upon a foundation of loose stone, in the same natural depth of water. The stone are shown as having been pressed downward to a distance of 3 feet below the natural bed of the lake by the superincumbent weight of the stone in the crib, and after its having been subjected to the action of the water. For the convenience of computation, it is shown in a more symmetrical shape than it would actually assume.

The quantity of stone contained in this artificial foundation, having a mean dimension of 28 by 4 by 32 feet, equals 3,584 cubic feet, or 128 cubic feet, which, at $8.25 per cord, would cost $231, showing an excess of $7.85 over the cost involved by the subsidence of crib placed upon the natural lake-bed. But it is assumed that the crib which is set upon a foundation of stone rests in a horizontal position, with its two upper courses above water-surface, while, in the first case, it has settled and tilted so that the seaward side is 2 feet below the surface, and the inner side at water-level, a mean horizontal of which would show it to be 1 foot below the surface of the water. It is clear, then, that a gain is effected by adopting the system of stone foundation, which is equivalent to three courses of crib-construction in value at the prices above specified, as follows, viz:

414 linear feet of framed timber, at 31 cents	$128 34
20 pounds of iron drift-bolts, at 4 cents	20 80
15 cords of stone ballast, at $8.25	82 50
Amount gained	231 64
Value excess of	7 85
Total amount gained by using an artificial foundation of stone	223 79

Or a saving of about $7 per running foot of pier.

Besides which, the cost of furnishing and driving the necessary piles for carrying the superstructure, the loss of timber occasioned by cutting wedge-pieces for leveling up the work, and the extra framing of the wedge-timbers, have not been taken into the account.

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Independent of these necessary considerations of means, the effectiveness and general appearance of the work should receive a proper share of consideration.

Various expedients will readily be suggested for placing the stone properly before setting a crib.

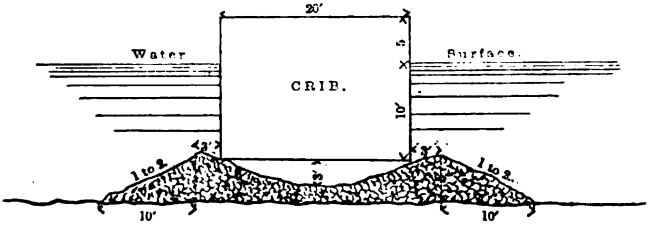
The advantage derived through this combined system has been fully demonstrated by practical experience at the harbor of Sheboygan, Wisconsin, during the present working season.

W. H. HEARDING,
Assistant United States Engineer.

SEPTEMBER 5, 1871.

In order to secure a nearly level bearing for the cribs, I would recommend that the stones be placed as shown in the cross-section below, *i. e.*, in two ridges, the crest of each ridge being placed about 3 feet outside of the sides of cribs. It will be easy to place the stone so that the crest of each ridge will be nearly level. The crib being placed between these two ridges will by its weight bring the stones nearly to a level bearing, and not be liable to be undermined.

In very bad bottoms it would be an improvement to place the stone in a *broad matting*, made of brush. This matting can be made of fascines bound together by withes. The fascines should be made of loose brush, including small branches and leaves, which have the effect of collecting the sand.



Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., December 16, 1871.

MAJOR: Your letter of November 29, submitting for the approval of the Chief of Engineers a modified cross-section for the breakwater at Chicago, has been received.

By reference to the annual report of the Chief of Engineers for 1870 and 1871 it will be seen that the appropriations for the breakwater at Chicago are based upon a plan of the Engineer Department, which was submitted to Congress. It is consequently not deemed advisable to make any radical alteration or modification in this plan, which has received the sanction of the Chief of Engineers after having been approved and recommended by a board of engineer officers.

In regard to the question of proper form of cross-section for pier and breakwater, it has been fully discussed in previous reports, and the weight of authority is largely in favor of a structure with almost vertical face on the seaward or exposed side. (*Vide* Report Chief Topographical Engineer, December 30, 1839, Doc. No. 2, Twenty-sixth Congress, first session, House of Representatives, and also Message and Documents, 1853-'54, part 3, and Message and Documents, 1854-'55, part 2, and also

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Report of Board of Engineers on Buffalo Breakwater.) (See Annual Report Chief of Engineers for 1868, page 233.)

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers.

Major D. C. HOUSTON,
Corps of Engineers, Chicago, Illinois.

UNITED STATES ENGINEER OFFICE,
Chicago, December 21, 1871.

GENERAL: I have the honor to acknowledge the receipt of your letter of the 16th instant in relation to the modified form of cross-section for the breakwater at Chicago, submitted with my letter of November 29.

I could not have been sufficiently explicit or detailed in my letter of that date, for it was not my intention to recommend any radical change in the plan approved for this harbor, or to indorse the principle of the long slope in deep water, in opposition to the vertical face which has been so highly recommended. Assuming the great advantage claimed for the vertical face over the sloping face composed of loose material, the question of foundation becomes of great importance; it is in fact the most essential element to the stability and permanence of the work. In nearly all the harbors under my charge the natural bed for cribs is sand, and it is found that even in the greatest depth of water, when cribs have, been sunk, (as at Marquette, in 28 feet of water,) the sand moves during storms, causing the cribs to settle unevenly, to tilt outwardly, (toward the exposed side,) and in some instances to shift their position.

It is, indeed, a rare case that a crib maintains the exact position in which it was first placed. The grillage bottom, which allows a portion of the stone to work through the sand, is a very partial remedy for these evils. The device of placing aprons of loose stone on the outside of the cribs has been resorted to with great benefit, but it is not satisfactory, and in many cases a storm comes up and shifts the crib by the undermining process before the riprapping can be put in. I do not know that this movement of the sand at great depths is evidence that the action of the waves extends so deep in the open lake when no obstruction exists; but our piers and breakwaters are generally placed at an angle with the line of direction of prevailing storms, and a current is produced, the action of which extends to the bottom of the work, and it is generally found that close to the pier the water is deeper than a few yards off. It has been my object to devise some economical plan of foundation for cribs on such bottoms to prevent this universal displacement, and with this view I have consulted freely with my assistants and contractors, who have practical acquaintance with the difficulties to be overcome, as well as all the authorities to whose writings I have had access. In the actual construction of piers during the past season the efficacy of "stone foundations" for cribs has been incidentally demonstrated.

At Du Luth, one of the cribs, soon after it was placed and but partially filled with stone, (about 100 cords,) was torn from its position by a heavy northeast sea, leaving the stone on the bottom. A new crib was placed

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over this, and maintained its position better than any previous crib. It was the sixth crib in the extension of the breakwater.

The loss in this instance fell upon the contractors, as they were required to fill the crib to the surface before accepting either the materials or labor. Taking advantage of this experience, a foundation of stone was put in for the next two cribs, which have stood well, although the seventh crib was not completely filled when it was exposed to the most violent gale of the season.

It is generally found that, when a pier is extended into the lake, immediately at the head of the pier a hole is made by the action of the waves extending outward some 20 or more feet, and of variable depth.

At Sheboygan Harbor, when, in the extension of the piers the past season, cribs 64 feet long were used, immediately at the end of the north pier there were found 20 feet of water, shoaling up to 12 feet, at a distance of 64 feet from the pier-head.

It was at first proposed to dredge out a level bed, but the uncertain expense attending the work, on account of the liability to fill up before the crib could be placed, and the necessity of dredging a channel, especially to float out a crib of the required depth of the harbor, caused me to adopt the plan of filling up the hole with rubble-stone. The result was another evidence of the efficiency of the stone foundation in such a bottom. In other instances, also, we were forced to resort to this plan, and hence I directed my assistant, Mr. W. H. Hearding, who has been exclusively employed in the construction of crib-piers for the past four years, to submit his views on this question. Other plans of foundations have also been considered, particularly that of piles sawed off near the bottom of the lake, but have been discarded, owing to the expense and delays incident to all operations in the lakes.

I then proceeded to apply the results of these investigations to the foundations of the breakwater at this harbor. Assuming the necessity for some solid foundation, and the efficiency of rubble-stone for this purpose, the questions were as to the width, the slopes of the sides, how near to the water-surface the top of this foundation should be, and the manner of placing the stone so as to secure a level bearing for the crib.

The consideration of these questions led to the cross-section submitted in my letter of November 29.

I consider it probable that I have placed the top of the foundation too near the surface of the water for the present work, viz, 4 feet, but I proposed at first to give the stone for the foundation a narrow base, as shown by the black dotted lines, and leave this exposed to the action of the waves until it should be practically determined at what depth the stone composing the foundation would remain undisturbed.

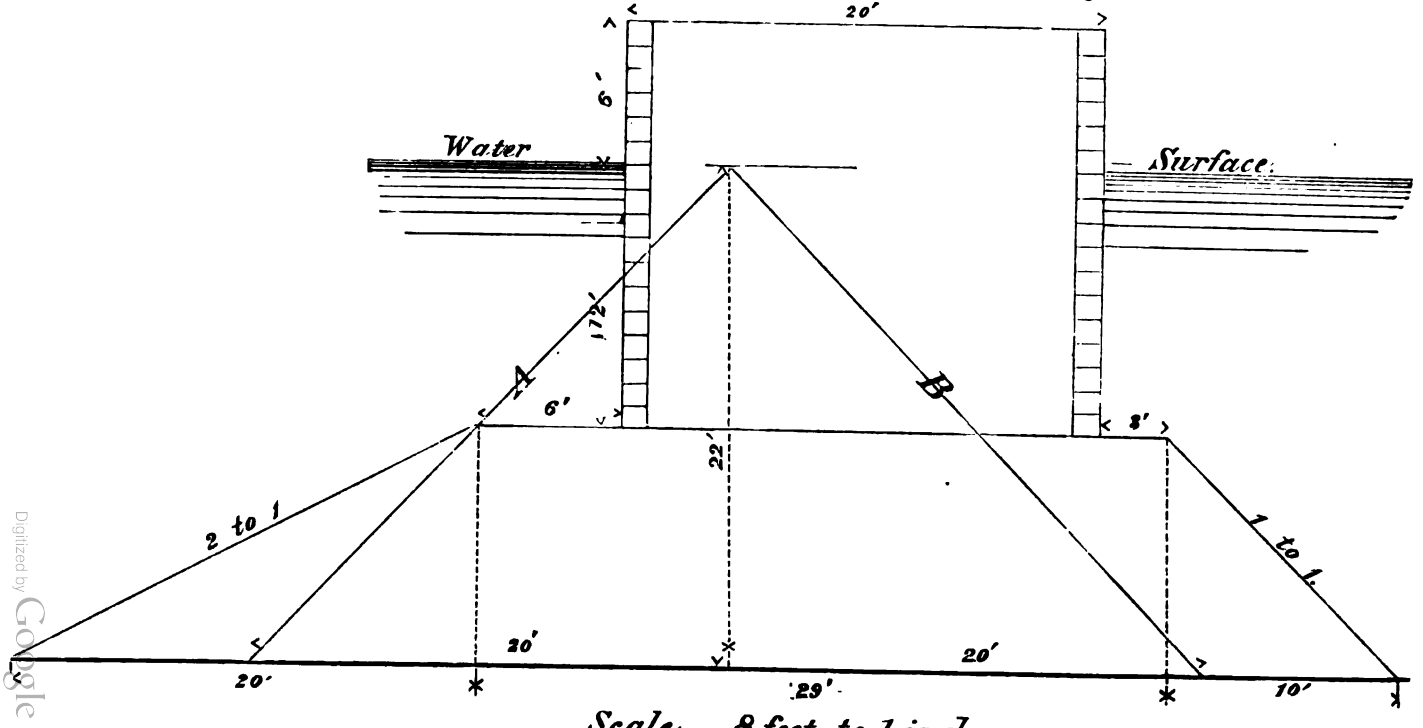
In practical construction I would make the first base as narrow as possible, so as to bring the stone up to the height indicated, and also narrowing the top.

The main point, however, which I intended to submit for your approval, was the importance of these stone foundations, which in this locality can be made as broad and deep as may be desired without increasing the present cost of the work, owing to the cheapness of stone and the facilities for handling it. It is asserted by English authorities, upon extensive evidence, that rubble-stone of the size we use will be undisturbed by the waves in the most exposed situations at a depth of from 10 to 15 feet. From my observations at this harbor, I think they will be undisturbed at a much less depth. This can readily be determined by experiment. I inclose a sketch (Fig. 5) giving a cross-section

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Proposed Cross Section for breakwater at Chicago. Ill.



Scale. 8 feet to 1 inch.

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with a foundation, the top of which is placed 12 feet below the water-level. The width of the crib-work is reduced to 20 feet, which is that given to all piers in 12 feet of water, and which experience has shown to be ample when there is a good foundation. Now, if this cross-section should be adopted, the question as to the depth at which the stone are disturbed by the waves could be determined without cost, by first placing the stone with the cross-section, shown by the lines A B, for a length of 100 feet, and allowing them to be exposed for a year. The result would enable us to decide what depth could be considered safe in the most extreme cases.

I have not the report of the board of 1853 with me, but my recollection is, that the crib-work was mainly adopted on account of economy, and that the portion of the work above water should eventually be replaced by masonry. The cross-section of a crib is necessarily rectangular, or nearly so, and its mass is calculated to withstand the shock of the waves in the same manner as enormous blocks of stone. Hence, the question of vertical or sloping exposure to the sea does not assume the same importance as in the case of harbors where stone only is used, either in the form of masonry or rubble. The form of cross-section, other things being equal, should be determined by the cost of the work.

While a vertical wall may, in theory, be the most suitable form for a breakwater, there are questions of locality, character of the bottom, exposure to storms, and accessibility of materials for construction, which would decide in favor of the other form of work on the score of economy.

The board of engineers convened in New York in 1867, of which Brevet Brigadier-General Hartman Bache was president, for the consideration of the breakwater at Block Island, was composed of members most of whom, I think, formed the theory of vertical exposure to the sea, yet, in the absence of any precedent for the construction of a breakwater with a vertical face in such an exposed locality, and with a sandy bottom, they were constrained to recommend a cross-section similar to the Delaware breakwater.

If it is assumed that the timber and iron used in the construction of cribs in lake-harbors are sufficiently durable to warrant the ultimate construction of a masonry superstructure, it is of the first importance that the cribs should be so placed as to be in close contact and good alignment. This cannot be accomplished without a good foundation.

A board of engineers has recommended an outer harbor at Michigan City, Indiana. From my observations at that harbor, I am satisfied that it would not be practicable to construct a breakwater without extra precautions as to foundation. During the present month the end crib on the west pier, which was placed in the summer of 1870, has moved from its position, but we have not yet been able to ascertain the extent of the displacement, as the pier is covered with ice. A breakwater at that place will, I think, require a broad base of stone, rising to within 15 feet of the surface, and allowed to remain at least one season, before placing the cribs. The place is very much exposed, and the material composing the bottom easily moved.

It is not my intention in this letter to urge the adoption of the cross-section submitted in my letter of November 29, but to ask your approval of the stone foundations, as shown on the accompanying sketch, or up to such a height as may be thought expedient.

It is simply an extension of the system aimed at by the grillage bottom and riprapping, as heretofore practiced.

I have never been able to satisfy myself as to the correctness of the arguments used in favor of the upright breakwater, and I take the

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liberty of inclosing, for your consideration, a statement of the views to which I have arrived on the subject.

Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

NOTES ON WAVE-MOTION AS RELATES TO THE FORCE EXERTED BY IT ON BREAKWATERS, SHORES, ETC.

If I understand the theory of the upright breakwater it is this: that in deep wate where the waves do not break they have simply an oscillatory motion, nearly vertical, and consequently the particles of water will move parallel to the face of the wall, and exert little if any pressure against it, except the hydrostatic pressure due to the height of the wave, whereas in the case of a sloping wall this oscillating motion is converted into a motion of translation, as on a beach, and the water is propelled forward with greater or less velocity, depending on the height of the wave. From which it follows that in water so deep that the wave does not break, an upright wall is the best form, but in cases where the water breaks before reaching the pier, an inclined slope affords the least resistance to the horizontal motion of the water, and allows it to rise gradually until the force developed has expended itself in overcoming the gravity of the water.

I have studied this subject with all the light I can find, and confess that I am not satisfied with this theory.

It seems to me, in case of a harbor formed in the open sea so as to inclose a portion of it, and cause smooth water inside, when, without the protecting works, there would be a heavy sea and tremendous surf on shore, that these works must be exposed to precisely the same force that formerly produced the motion inside; in other words, that the force to be resisted is that formerly resisted by the shore. All force must do its work. According to the upright-theory all that would be necessary for a breakwater in deep water would be a vertical wall of sufficient weight to withstand the hydrostatic pressure of column of water due the greatest height of the waves, or the difference of level on the two sides of the wall, which would only require a masonry wall a few feet thick.

It seems to be contended that a vertical wall has no resistance to overcome, but if you put a sloping wall, a tremendous force is developed, and that there is some mysterious power in a mathematical figure by which a power is suddenly created. This seems absurd, yet it is a fair conclusion from the statements of many of the advocates of a vertical wall.

The fact is that a certain resistance must be overcome, which is entirely independent of the form of cross-section, and the question is simply as to the best disposition of the materials at our disposal to afford this resistance.

The instance of a boat lying along a ship's side, a wharf, or a vertical cliff in a heavy sea, is repeatedly offered as an argument in favor of the vertical wall, and it is inferred that because the boat is not driven forcibly against the cliff, that there is no force exerted against the latter.

A consideration of mechanical principles, as developed in wave-motion will, I think, show that this does not prove anything of the kind, and it will not be necessary to adopt any theory of the motion of the particles of water, but simply to apply well-known principles. The motion of the boat merely shows that the motion of the water is, *on the surface*, vertical or nearly so.

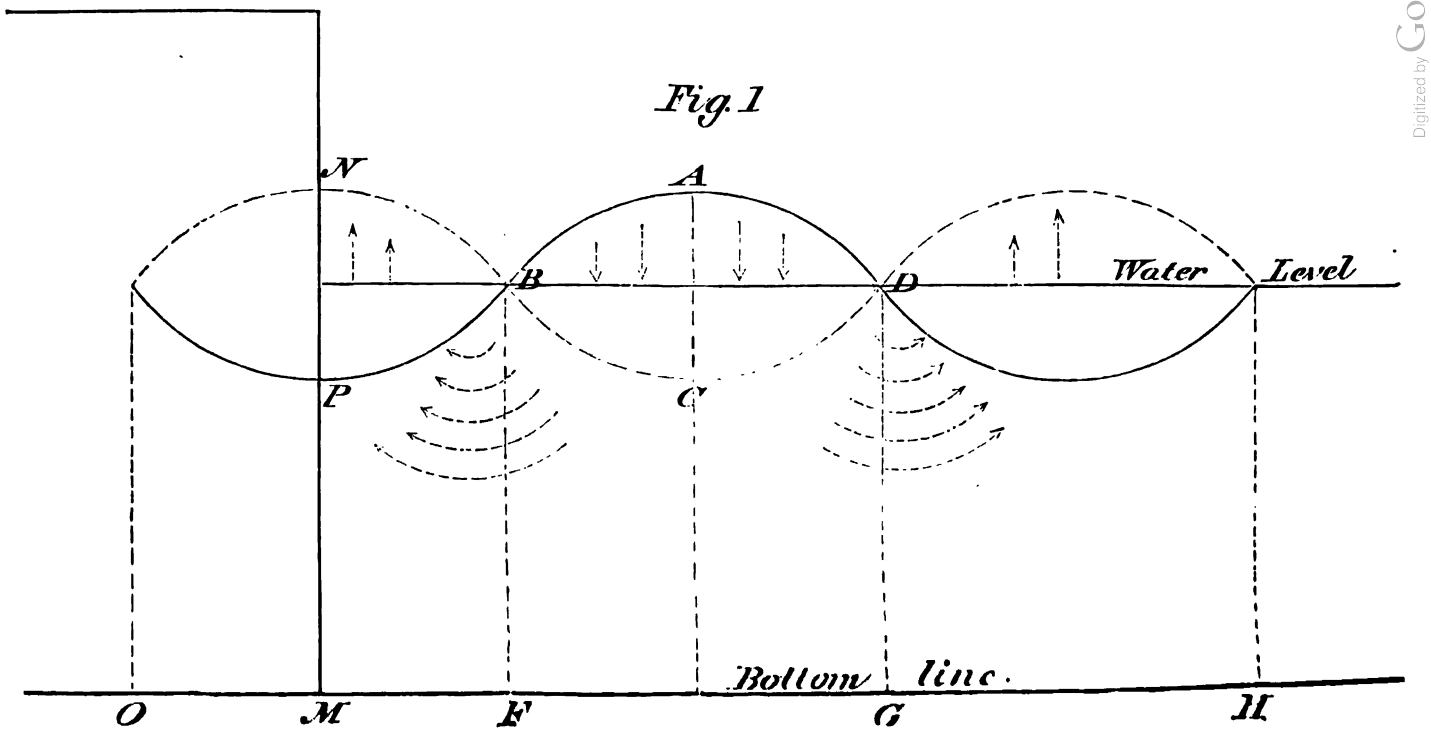
The accompanying diagrams (Fig. 6) illustrate the motion of waves and the effect of obstructions. The full black line shows the surface of the wave at a given instant; A N is the length of the wave, and the dotted line shows its surface after the wave has moved a wave length.

Now in this length of time the column of water above F G has diminished by the quantity A B C D, while the columns above O F and G H have each increased by the same quantity.

As water is an incompressible material, it follows that a quantity of water equal to

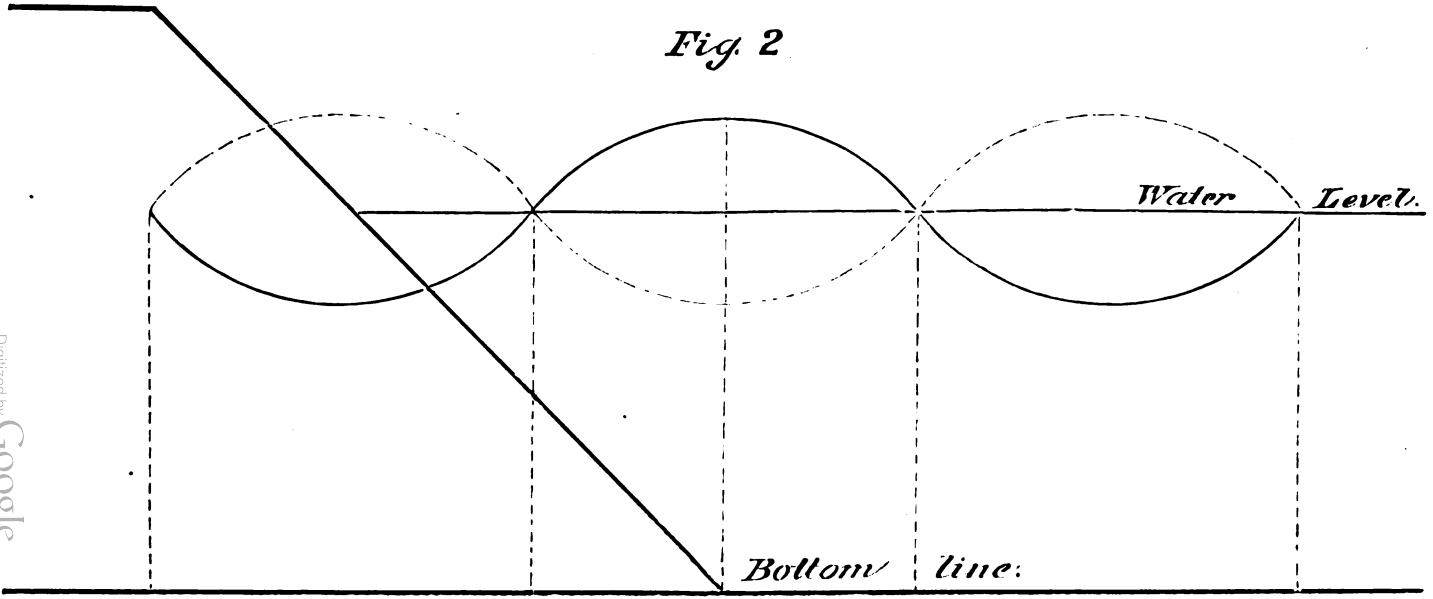
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Fig. 6.



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Fig. 6.



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A B C D must have been moved horizontally from the column A B F G D during the time that the crest of the wave moved from A to N.

We know by observation that the water at the surface does not move horizontally, consequently the water below the surface must have been moved laterally by the pressure of the descending column.

It may be stated generally that if the surface of water is suddenly raised, as in the case of a wave extending over a considerable distance, while the surface on either side is lowered, there must be a corresponding horizontal motion below, backward and forward, (oscillating,) the momentum due to which is precisely the same as that due to the vertical motion. The quantity of this motion is the measure of the wave-force.

If we take a wave 15 feet high, 1,100 feet long, moving with a velocity of 5,500 feet per minute, an observed case, we have for the measure of the wave-force (approximately) for each linear foot of the wave measured perpendicularly to the direction of its motion; the motion of about 250 tons of water through a distance of 7½ feet in twelve seconds. At least half of this force would be exerted against each linear foot of a breakwater, which would have to sustain a blow equal to that produced by a ton of water falling through a distance of 95 feet, five times a minute.

$$250\times .625=156=M\,V$$

$$\frac{M\,V}{2}=78 \quad \frac{M}{2}=1 \quad V=78 \quad V^2=29h\,.\,29=64$$

$$h=\frac{78^2}{64}=\frac{6084}{64}=95$$

This is the force to be overcome whatever form of breakwater is adopted.

If we interpose a vertical wall at M N, as shown in Fig. 1, and consider the wave to occupy, first, the position shown by the full black line, and, second, that shown by the dotted line, we see that the quantity of water in the column above M F has been increased by the quantity N P B, and as the surface moves vertically, there must have been this horizontal motion below, the whole force of which is expended directly against the face of the wall.

Fig. 2 shows an inclined wall where but a portion of the force is expended on the face of the wall, one component being expended in forcing the water up the incline. When the incline is very great we have the case of the breaking wave.

The water in its horizontal motion in shoal water experiences more or less friction from the bottom; the motion at the top is consequently more rapid, the wave becomes steeper on the forward slope, and eventually topples over, and the force is expended in driving the water up the incline.

When the wave falls the water flows back, forming the undertow or reverse current. This is the water which is moved horizontally by the wave-motion, which must return, otherwise the whole surface would rise, as it does to some extent in heavy gales. Now, it seems to me from these considerations that the best form, mathematically speaking, to be given to a breakwater, is a long slope or wedge, perhaps curved toward the sea, and that this form requires the least strength, as it has only to resist a small component of the wave-force. Breakwaters, however, of this form have always been composed of loose materials easily moved, and, in order to get this form, enormous quantities of material have been used to furnish a base, while in upright breakwaters masonry has been employed, so that the shock is sustained by the entire mass of the work.

If sloping breakwaters were constructed in the same manner, we should not hear of the injuries which they have sustained.

The objection to sloping breakwaters is their mode of construction, not their form. It will be interesting to consider the manner in which the force of the wave is exerted against a vertical wall. We know by observation that it is not the surface-water which moves horizontally, consequently it is the water below the wave-action that is pressed forward by the movement downward of the surface. How far down this motion extends is not satisfactorily determined, to my knowledge, but it depends on the height of the wave and the depth of water. The motion will be, however, below the surface, and the particles of water will probably move in curved lines having their convexity downward.

If a vertical obstacle is interposed, they will be reflected, and meeting the pressure of the following particles will rise up along the face of the work.

The inward movement of the waves being checked when these particles fall, a reverse wave occurs, and we have an exhibition of wave interference and coincidence, such as I saw last summer in Lake Superior, off the Pictured Rocks, which offer a very steep angle to the waves.

I left Grand Island Harbor early in the morning in a small tug, with a breeze off shore, but as we emerged into the lake, passing along the Pictured Rocks, we encountered a heavy sea, but no wind. Passing on eastward of the rocks, where there was a sloping sand-beach, the sea quieted down considerably, but by noon, when we arrived

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at Grand Island Harbor, we were overtaken by a northwest wind, which had evidently been blowing at a distance all the morning, and caused the sea which we experienced. Now, I infer that the heavy sea which we encountered off the rocks was caused by the reflection of the waves from the almost vertical cliffs, which, consequently, received the whole force of the wave and sent it back on itself, while on the sloping beach this force was expended in rolling the water up the gentle slope until it was overcome by gravity, and then this water flowed gently back as an undertow, causing a reverse current along the bottom, and without affecting the surface-wave. In addition to the wave-motion which I have endeavored to describe, there is also the horizontal motion of the surface-water, produced by the wind acting upon the crests of waves. As this motion is horizontal, it would seem evident that the sloping form of obstruction is best adapted to resist it.

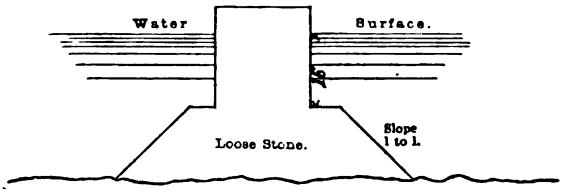
Although I cannot agree with the theory which argues that the vertical wall *has less resistance to overcome* than the inclined wall—for it is evident to me that this resistance is independent of form—I do not condemn the vertical system in all cases. I believe it practicable in many instances (and there are examples) to construct a vertical wall which will be preferable to the other plan, but it must have a good foundation, and be in every respect a much more substantial work than is required for the sloping form.

In all cases where substantial vertical walls have been built great care has been taken with the foundation, and great thickness has been given to the work.

In shoal water, where the wave breaks before reaching the breakwater, I think the sloping form is the best.

When large, heavy cribs of timber filled with stone are used, it is mainly important that the foundation on which they are placed be prepared so as not to undermine Owing to the great mass which can be given to the cribs, the question of cross-section becomes less important.

The cross-section which seems to be most suitable in the general case is that shown in the marginal sketch. The lower portion is composed of loose stone, and is only



brought up to a height *where it is not affected by the waves*. The upper portion is of masonry.

The worst form of breakwater is the long slope, brought up to just above the water-level and then surmounted by a parapet. The latter is then placed so as to receive in a limited space the (almost) entire wave-force.

D. C. HOUSTON,
Major of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 5, 1872.

MAJOR: Yours of December 21, in reply to letter from this office of December 16, in relation to the modified cross-section proposed in your letter of November 29, for the breakwater at Chicago, Illinois, has been received.

For the reasons given, and in accordance with your recommendation, you are authorized to so far modify the project as to introduce the stone foundations for the cribs used in the breakwater, the cross-section and dimensions of this foundation to be such as your judgment and experience may dictate. It is not deemed advisable to have the top of the stone foundation approach nearer to the water-surface than 12 feet.

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Should further examinations and observations, however, warrant any change in this depth, you will please make report to this office.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers.

Major D. C. HOUSTON,
Corps of Engineers, Chicago, Illinois.

A 24.

SURVEY FOR A SHIP-CANAL FROM HEAD OF STURGEON BAY, WISCONSIN

UNITED STATES ENGINEER OFFICE,
Chicago, November 29, 1871.

GENERAL: I have the honor to transmit herewith a report by Assistant William T. Casgrain, of a survey "for a ship-canal from the head of Sturgeon Bay, Wisconsin, on the line now opened across the Portage through the timber to the shore of Lake Michigan, with estimates for constructing the same 100 feet wide and 13 feet deep," called for by the act of Congress dated March 3, 1871.

A very careful and thorough survey of this route was made by Mr. Casgrain, and the report and map were nearly complete; but these were destroyed by the Chicago fire of October 9 and 10, 1871. Sufficient memoranda, however, were preserved to enable us, by the aid of the lake-survey charts, and memory, to give the result of the survey for all practical purposes.

The borings which were taken show no material but what can be removed by dredges. The highest point on the first of the two routes examined is 32 feet, on the second 28½ feet, above the lake.

The proposed canal, for which estimates are submitted, is 100 feet wide at bottom and 13 feet deep. The slope of the excavation above water is two base to one perpendicular.

The sum of $144,000 is estimated for revetting the banks of the canal, which, owing to the character of the material, is necessary to complete the work, but may not be required to the extent of the estimate, nor until after the canal has become navigable.

At the lake-terminus of the canal are two piers, extending out to a depth of 18 feet of water, which are necessary to protect the channel excavated in the lake. The object of giving the piers the oblique position indicated is that a width of not less than 200 feet between the ends of the piers is necessary for the easy passage of vessels, and if the piers were placed parallel to the angle of the canal, which is only 100 feet wide, a heavy sea would be created at the mouth; but by giving them the position indicated, the sea will have an opportunity to spread out, so that by the time it reaches the mouth of the canal it will have lost much of its force. The price estimated for dredging is high, but will, it is thought, cover all contingencies.

Observations were taken to determine the difference of level between the lake and Sturgeon Bay, which was found to vary according to the force and direction of the wind. Strong southerly winds caused a rise in the lake and a fall in the bay. 'On one occasion, about July 10, the water in the bay fell 3 feet below the lake-level, and so remained for about half an hour. A similar phenomenon was observed about this

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date at Green Bay, and at Du Luth, Minnesota. Such a variation, however, rarely occurs, and it is seldom more than 6 inches either way. It is possible that at times the current through the canal may be so great as to interfere somewhat with its navigation, but not, it is thought, to an extent rendering guard-gates necessary.

The three general items of the estimate are:

For excavation from deep water at Sturgeon Bay to lake...	$369,300
For piers to protect channel in lake.....	116,000
For revetment of banks of canal	144,000
Total	629,300

Very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Chicago, November 21, 1871.

MAJOR: I have the honor to submit the following report and estimates relating to the survey of the Sturgeon Bay Ship-Canal, which survey was made in obedience to your orders of June 18, 1871.

Owing to the disastrous conflagration which visited the city on the 9th of October, when the greater portion of the field-notes of the survey were destroyed, the map accompanying this report is not as complete as it should be.

The soundings in Lake Michigan have been compiled from the notes of the United States lake survey, taken in the summer of 1867, and reductions made for the comparative stage of water between that period and last summer.

The profiles and cross-sections levels were destroyed, and I am unable to furnish them at the present time. I obtained from the notes of the lake survey the profile of the Portage Road, which I have shown to give a general idea of the elevation above the water-surface of Lake Michigan. Fortunately, I saved the greater part of the estimates submitted in my first report, and I am thus able to furnish a reliable statement.

The act of Congress authorizing a survey to be made at that point reads as follows, viz: "For a ship-canal from the head of Sturgeon Bay, Wisconsin, on the line now opened across the Portage through the timber to the shore of Lake Michigan, with estimates for constructing the same 100 feet wide and 13 feet deep."

In compliance with this law, a thorough survey of the line above described was made. But upon a careful examination of the country south of this line, I became satisfied that a shorter and more direct route could be found, which would reduce the cost of construction. Accordingly I made a complete topographical survey of that part of the Portage south of the old line, and from the data obtained located a line which proves to be some 250 feet shorter and an average of 2.1 feet less cutting than on the old route. The advantages of this route over the old one will be better understood by referring to the map.

There will be two angles in the canal on the proposed old route, whereas on the new line we shall have a straight channel through the Portage, on the prolongation of the center of the head of Sturgeon Bay. This will be particularly advantageous to vessels making the passage, as it will afford them better facility to see and pass each other in the canal.

Careful borings were made on both routes at every 500 feet, and samples, taken at different depths, showing the character of the soil, were preserved. These samples were lost in the conflagration. However, I have obtained from Mr. William L. Baby, the foreman of the boring-party, some of the notes taken from his private diary, which enables me to give a general idea of the character of the soil at each boring-station, and is shown on the profile. Each boring was made from 10 to 20 feet deeper than the proposed line of the canal, so as to ascertain the nature of the soil for the pile-revetment. There were reports that the bottom of Lake Michigan, at the Portage, was underlaid with a bed of limestone; careful borings were made, which show the existence of loose stones and bowlders, but no rock.

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STURGEON BAY AND VILLAGE.

About half-way from the head of Green Bay to its junction with Lake Michigan, through "Porte des Morts," or "Death's Door," is Sturgeon Bay, running in a southeasterly direction. It is about eight miles in length by two in breadth at its mouth, gradually narrowing to about one-quarter of a mile at its head. Its waters are clear, and deep enough to float the largest of our lake-crafts. Its shores are occasionally dotted with cottages and farms, while the rest are thickly wooded with a variety of timber. The land is undulating, and gently sloping down to the water's edge. The only marsh and low lands are found at the head of the bay.

On the north side of the bay, and about five miles from its mouth, on a small promontory, having an elevation of forty or fifty feet above water, is situated the village of Sturgeon Bay. Its population is about five hundred inhabitants. It has two churches, three steam saw-mills, three hotels, two stores, and a post-office.

The manufacturing interests have not been developed as rapidly at this point as on the west shore of Green Bay, for the reason that on the peninsula the pine timber is found only in limited quantities, and we are confined to a narrow belt of land; but no part of Green Bay presents as great facilities for iron-furnaces and tanneries; the hardwood timber, for charcoal, and the limestone, for flux, are found in inexhaustible quantities, as well as an abundance of hemlock to supply the bark for the tanneries.

ADVANTAGES OF THE CANAL.

1. These will consist in avoiding the present dangerous channels through "Porte des Morts," or "Death's Door," where many valuable vessels and their cargoes are lost. We find at the entrance to Green Bay by Porte des Morts several reefs and shoals obstructing the safe navigation of this channel, such as the detached reefs between Pilot Island and the main shore, and the reefs southeast of Gravel Island, as also the Whale's Back, nearly abreast of the Door. In the passage north of Rock Island we find two detached reefs in a southeasterly direction, and between it and Saint Martin's Island, though the passage is much wider, two small shoals are found nearly in the center of it.

There is a strong current through Death's Door, setting in or out according to the direction of the wind, and many valuable vessels have been lost in consequence thereof. The coast is rock-bound, and it is almost certain destruction to the craft going ashore.

2. The immense quantity of freight shipped from all points along Green Bay is carried by a fleet of over two hundred vessels, which would make a total of at least six thousand passages annually to Chicago and other ports on Lake Michigan.

3. To convey some idea of the large fleet of vessels engaged in the Green Bay trade, I have kindly been furnished by Mr. S. P. Drew, light-house keeper at Green Island, a record of the number of vessels which passed the light-house during the following years, viz, in 1868, 7,338; in 1869, 7,347; in 1870, 7,369.

4. The distance from Chicago to Green Bay, Big and Little Suamico, Pensaukee, Oconto, Peshtigo, and Menomonee will be shortened on each round-trip one hundred and fifty miles, or about one-sixth of the entire distance.

5. For Escanaba, where nearly three-fourths of the Lake Superior iron-ore are shipped, the canal will be especially useful. At certain seasons of the year, in the spring and fall, when the weather is too stormy on Lake Michigan, sailing-vessels could avail themselves of the Green Bay route, which is comparatively well sheltered, and make the run to Sturgeon Bay, where they could wait for fair weather to resume their journey.

6. In addition to the above advantages, we must also consider the rapid growth and development of the resources of the country in and around Green Bay.

The late discoveries of iron-ore along the Menomonee River and vicinity will soon give an additional impetus to the commerce of Green Bay.

7. The improvement of the Fox and Wisconsin Rivers, which, when completed, will make the connecting link between the Mississippi and the lakes, and furnish additional facilities for shipping the produce of Northern Wisconsin and that of the grain-growing States on and beyond the Mississippi. We cannot safely predict what the increase may amount to in the next ten years, but that the commerce will grow, and rapidly, there is no doubt in my mind.

During the summer, and while prosecuting the survey, the Hon. J. Harris, of Sturgeon Bay, through circulars sent to all the manufacturers in Green Bay and vicinity, collected the following statistics of the trade and commerce of Green Bay for the year 1870:

Lumber, manufactured, feet	500,000,000
Shingles, manufactured, feet	900,000,000
Lath, manufactured, pieces	340,000,000
Pickets, manufactured, pieces	35,000,000

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Railroad-ties, manufactured, feet	2,500,00
Cedar posts, manufactured, pieces	1,600,00
Staves, manufactured, pieces	2,200,00
Telegraph-poles, manufactured, pieces	650,00
Wooden-ware, manufactured, pieces	11,697,00
Evergreens, number	6,400,00
Cord-wood, cords	70,00
Tan-bark, cords	12,00
Flour, barrels	160,00
Fish, barrels	40,00
Salt, barrels	33,00
Wheat, bushels	340,00
Oats, bushels	160,00
Hay, tons	14,00
Pig-iron, tons	45,00
Iron-ore, tons	630,00

The total value of these exports is estimated at $65,000,000, and the value of import such as mill supplies and merchandise, is estimated at $24,000,000.

There are over one hundred saw-mills in operation along the shore of Gre Bay, employing about fifteen thousand men, and the capital invested is estimat at $100,000,000.

Estimate of the cost of constructing a ship-canal between the head of Sturgeon Bay and La Michigan on the "old route," as located by J. E. Thompson, civil engineer, in 1867.

Piers in Lake Michigan, each 1,300 feet long, 800 feet of pile-pier, 14 feet wide, at $30 per linear foot	$24,000
750 feet of crib-pier, 20 feet wide, at $50 per linear foot	37,500
950 feet of crib-pier, 25 feet wide, at $75 per linear foot	71,250
100 feet of crib-pier, 30 feet wide, at $120 per linear foot	12,000
18,500 linear feet of pile-revetment, at $8 per linear foot	148,000
6,600 linear feet of line, cut and cleared, 600 feet wide, at $2	13,200
Wet excavation in cut, 420,000 cubic yards, at 50 cents	210,000
Wet excavation in Lake Michigan, 40,000 cubic yards, at 50 cents	20,000
Wet excavation in Sturgeon Bay, 50,000 cubic yards, at 40 cents	20,000
Dry excavation in cut, 570,000 cubic yards, at 30 cents	171,000
Total cost	726,950

Estimate of the cost of constructing a ship-canal from the head of Sturgeon Bay to Lake Mi igan on the "new route," as located by William E. Casgrain, assistant United States gineer, in 1871.

Piers on Lake Michigan, each 1,050 feet long, 800 feet of pile-pier, 14 feet wide, at $30 per linear foot	$24,000
400 feet crib-pier, 20 feet wide, at $50 per linear foot	20,000
800 feet crib-pier, 25 feet wide, at $75 per linear foot	60,000
100 feet crib-pier, 30 feet wide, at $120 per linear foot	12,000
18,000 linear feet of pile-revetment, at $8 per linear foot	144,000
6,400 linear feet of line, cut and cleared, 600 feet wide, at $2	12,800
Wet excavation in cut, 380,000 cubic yards, at 50 cents per yard	190,000
Wet excavation in Lake Michigan, 35,000 cubic yards, at 50 cents per yard	17,500
Wet excavation in Sturgeon Bay, 50,000 cubic yards, at 40 cents per yard	20,000
Dry excavation in cut, 430,000 cubic yards, at 30 cents per yard	129,000
Total cost	629,300

The above piers including engineering, superintendence, and 10 per cent. for conti gencies.

Cost of constructing ship-canal on old route	$726,950
Cost of constructing ship-canal on new route	629,300
Difference in favor of new route	97,650

Respectfully submitted.

WM. T. CASGRAIN,
Assistant United States Engineer

Major D. C. HOUSTON,
Corps of Engineers, U. S. A., Chicago, Illinois.

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DETROIT, MICHIGAN, *October* 28, 1871.

SIR: The following summary of operations is respectfully submitted, relating to the survey and explorations of the "Sturgeon Bay and Lake Michigan Ship-Canal," to supply as far as possible the loss caused by the disastrous fire in Chicago, where it would appear all the maps, notes, specimens of boring, &c., &c., were lost.

About the 26th of June, 1871, agreeably to your instructions, I commenced, with the aid of two or three men, to construct a derrick for the use of the boring-rods made in Chicago, which we had brought with us. The derrick was accordingly constructed, and was composed of three pieces of pine scantling 18 feet long and 4 inches square, with an inch bolt and nut to keep them together on top, and two sets of braces, 2 by 4 inches scantling, with half-inch bolts and nuts. One set was screwed on to the legs of derrick 18 inches from the ground, and the other set about 10 feet from it. This was not only to strengthen it, but served the good purpose of supporting a movable platform through which the boring-rod was passed, keeping it perpendicular. A windlass of white oak, 8 inches in diameter, was fastened to the derrick with iron straps, which could be removed at pleasure, and at either end handles 1¼ inches thick inserted crossways. This windlass was used to draw up the boring-rod, as occasion required, and was furnished with an inch rope and a pair of double blocks.

I think it was about the 3d of July that we commenced boring on the "old cut," 60 feet from the water's edge of Sturgeon Bay, and the center of the "cut," which is 100 feet wide, in flat swampy ground at stake 0, and penetrated in one day's boring 51 feet, which proved to be muck and sand till reaching the 51st foot, when, on drawing up the rod, blue clay was found in the worm of the auger. We then moved 500 feet in a line to the next station, borings being made at every 500 feet, when we again sunk to 40 feet in sand and fine gravel.

At station 3, or 1,000, to 42 feet in sand and gravel.
At station 4, or 1,500, to 40 feet in sand and gravel.
At station 5, or 2,000, to 44 feet in sand and gravel.
At station 6, or 2,500, to 40 feet in sand and gravel.
At station 7, or 3,000, to 42 feet in sand and gravel.
At station 8, or 3,500, to 44 feet in sand and gravel.
At station 9, or 4,000, to 40 feet in sand and gravel.

At station 10, or 4,500, east side of the Buffalo Ridge, four or five borings were made round this station, and from 9 to 20 feet only were reached. The soil was sand, gravel, and loose stones; very hard boring.

At station 11, 42 feet 7 inches were reached, occupying three days of excessively hard work, and a very fine sample of red clay was secured at that depth, the soil above being coarse sand and gravel.

At station 12, 40 feet in two hours were reached, through fine sand.

At station 13, 15 feet, after several ineffectual attempts to penetrate further. From that point to the lake, from 9 to 20 feet only were reached at the remaining different stations, and, with the exception of three or four samples of clay, they were all of sand.

In a great measure the defect in the joints of our boring-rod proved a great obstacle to our penetrating deeper on this line, and which was afterward remedied on the new one, as will be hereafter explained.

A successful boring of 15 feet in depth through sand was made about 900 feet from shore, in 15 feet water, and in line of center of "old cut," and the sample washed out the worm of auger in drawing up.

The task of getting the two scows in order and lashed together, after being sunk in the lake, requiring extraordinary labor and promptness to seize the favorable moment, is due to you, I may safely say, alone.

On August 10, moved to new line, or route, with our two scows lashed together, as on former occasions, and our derrick astraddle. The scows were firmly anchored to keep them in position, and another successful boring made 14 feet deep through sand, in 15 feet water, about 700 feet from shore, opposite triangulation-station K, and in line of center of new route. At that depth, stone and coarse gravel were struck and the rod pulled up, not being able to penetrate farther.

Second boring on this route, about 50 feet from water's edge, and immediately below the bank at station K, sunk 16 feet and struck stone, or coarse gravel, and pulled up.

Third boring at stake 61, ran down 15 feet, and broke our joints; soil, coarse gravel and stone. We had been hitherto so much troubled and put to serious inconvenience and expense, in consequence of this repeated mishap, that we now concluded to do away with them, so we had two rods of iron 16 feet long—same size of rods, 1¼ inch—welded together, and one of our old joints, with a strong auger, made by the village smith of Sturgeon Bay, welded to it, which answered admirably, and were not afterward troubled with so serious a defect; our rod was now 36 feet 4 inches in length, and we had little trouble in carrying it, and raising and letting it fall by the use of the derrick.

Fourth boring, moved derrick between stakes 47 and 48; reached depth of 22 feet in coarse sand and gravel.

Fifth boring, at stake 4,000, we succeeded in getting down 25 feet; very hard boring; coarse sand and gravel.

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Sixth boring, at stake 3,000, penetrated to the depth of 30 feet; easier boring; sand.

Seventh boring, at station 2,000, reached a depth of 33 feet in two hours twenty minutes; easy boring, and meeting with no obstructions; all sand.

At stake 1,000 reached 25 feet in two hours, and one man could have easily tur the rod, so easy was the labor; muck and sand.

I have endeavored to embrace the principal features of this interesting operatio the best of my ability, and only hope they may prove acceptable to the parties in ested, and have the honor to remain,

Very respectfully, your obedient servant,

WILLIAM L. BABY,
Having had charge of Boring-Part

WILLIAM T. CASGRAIN, Esq.,
United States Engineer, Chicago, Illinois.

APPENDIX B.

ANNUAL REPORT OF MAJOR F. U. FARQUHAR, COR OF ENGINEERS, JULY 1, 1871, TO JUNE 13, 1872.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wisconsin, June 13, 187

GENERAL: I have the honor to make the following report of o ations at harbors under my charge, from July 1, 1871, to June 1872.

Very respectfully, your obedient servant,

F. U. FARQUHAR,
Major United States Engineer

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

B 1.

FRANFORT, (AUX BECS SCIES,) MICHIGAN.

The contract of William Nicolls, awarded April 17, 1871, for fram and sinking three cribs, 64 feet by 20 feet, was completed by sinking t cribs, one on each pier-extension, and building superstructure o these cribs and the one sunk on north pier extension in fiscal year e ing June 30, 1871. Stone and timber were purchased in open marke the same rates as contracted for by C. S. Stevens, whose contract annulled.

The north pile-revetment of 1867 has been reballasted with brush stone.

The detailed cost of work and materials for the past fiscal year as follows:

4,492 cubic feet pine timber, at 13 cents per cubic foot	$58
6,511 cubic feet hemlock timber, at 11 $\frac{7}{10}$ cents per cubic foot	76
58,192 feet, board-measure, pine timber, at $13 per thousand feet	75
199 cords of stone, at $9.87 per cord	1,96
55 cords of stone, at $10.50 per cord	57
575 pounds of drift-bolts, at 3 $\frac{8}{10}$ cents per pound	2
Rehauling 178 cords of stone, at $2.25 per cord	40
Framing 15,479 cubic feet timber, at 12 cents per cubic foot	1,85
Furnishing in pier 350 cubic yards brush, at 97 cents per cubic yard	33

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Furnishing in pier 21$\frac{24}{100}$ cords slabs, at 50 cents per cord	$10 97
Dredging 3.23 days, at $104 per day	335 92
Labor	310 05
Superintendence	1,977 93
Advertising	121 56
Total	10,028 37
Amount on hand July 1, 1871	$9,844 45
Forfeited by C. S. Stevens on contract of November 11, 1870	185 57
	10,030 02
Less amount expended during fiscal year, to date	10,028 37
Amount on hand June 13, 1872	1 65

A bad bar has formed at the western entrance to the channel. This cannot become a harbor of refuge until the piers have been extended into deep water, beyond the outside bar. The present piers are in good condition.

B 2.

MANISTEE, MICHIGAN.

There were sunk last season by R. P. Thurber, under contract of April 17, 1871, six cribs, extending each pier 158 feet, with two cribs 64 feet by 20 feet, and one crib 30 feet square. Thurber, failing to do more than begin the superstructure over these cribs, his contract was annulled. This spring the work was resumed by hired labor, and the framing of superstructure and pier-head for south pier is already completed.

Stone was furnished by C. Fitzsimons, under contract of August 27, 1870.

Timber was bought in open market, after the contract of C. S. Stevens had been annulled. The Manistee fire of October 8, 1871, destroyed, with a large portion of the town, 10,755 cubic feet of pine timber, 406 cubic feet of oak timber, Government property, and burned the superstructure from 115 feet of the south pier at the east end. This destruction of timber so delayed progress that the proposed work of revetting and protecting that portion of north channel-bank, east from the present pier, was but commenced at the close of the season.

The detailed cost of work and material was as follows:

107,257 feet, board-measure, pine timber, at $11.85 per thousand feet	$1,270 98
82,220 feet, board-measure, pine timber, at $16 per thousand feet	675 52
1,212 cubic feet pine timber, at 21 cents per cubic foot	254 52
486 91 cords of stone, at $10.40 per cord	5,063 85
3,906 pounds of screw-bolts and washers, at 5 cents per pound	195 30
102 Norway-pine piles, at $2 per pile	324 00
75 Norway-pine piles, at $1.75 per pile	131 25
Furnishing and framing 205 cubic feet oak timber, at 50 cents per cubic foot	102 50
Tools	69 68
Rehandling 296.36 cords of stone, at $2 per cord	592 72
Framing 20,598 cubic feet timber, at 10 cents per cubic foot	2,059 80
Framing 3,677 cubic feet timber, at 15 cents per cubic foot	551 55
Dredging site for cribs	199 00
Labor	460 15
Repairs and dredging-apparatus	3,779 80

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Superintendence	$1,91
Advertising	3
Total	17,6
Amount on hand July 1, 1871	$20,00
Forfeited by C. S. Stevens, on contract September 8, 1870	13
Forfeited by R. P. Thurber, on contract April 17, 1871	26
	20,39
Less amount expended during fiscal year to date of report	17,6
Amount available June 13, 1872	2,71

There is now a greater depth of water between the piers than thro the river above. The work now progressing with the funds on h will leave the piers complete, with substantial pier-heads, and with repairs necessary.

The danger of a breach in the east end of north pier still exists.

B 3.

PÉRE MARQUETTE, MICHIGAN.

Under contract with Duncan Dewar, dated May 5, 1871, a pier-l 30 feet square was framed and placed on the north pier-extension, both this crib and the one forming the south pier-head were decked heavy planking and thoroughly protected by oak fenders,

Pile-pier, a length of 135 feet, connecting the south pier with shore, has been built.

The United States dredging-apparatus was employed at this ha until September 21, 1871, at first in dredging the channel, and a ward in the difficult work of removing slabs from the old slab which obstructs the south side of the channel.

In detail the cost for the fiscal year was as follows:

6,716.1 cubic feet pine timber furnished and framed, at 25 cents per cubic foot	$1,6
748.71 cubic feet oak timber furnished and framed, at 30 cents per cubic foot	2
125.4 cords of stone furnished in pier, at $14 per cord	1,7
17,826 pounds of iron drift and screw bolts, washers, strap-irons, and spikes, average price $4\frac{3}{10}$ cents per pound	7
570 linear feet Norway-pine piles, at 10 cents per linear foot	
2,071 linear feet of oak piles, at 15 cents per linear foot	3
145.74 cords slabs furnished in pier, at $2 per cord	2
192 piles driven, at $1.70 per pile	3
Dredging	
Labor	1,9
Superintendence	1,6
Advertising	
Total	9,7
Amount on hand July 1, 1871	$9,7
Less amount expended during fiscal year to date	9,7
Amount on hand June 13, 1872	

As predicted in the last annual report the sand has accumul beyond the west end of the old slab pier, which so much obstruct channel. The depth of water in the channel-way is now 9 feet. repairs are necessary.

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B 4.

PENTWATER, MICHIGAN.

The contracts with Messrs. Corlett & Hewly for pier-building, and with T. Stewart White for dredging, awarded May 4 of the fiscal year ending June 30, 1871, were completed during the fiscal year ending June 30, 1872.

The work done embraces a pier-head 30 feet square, well fendered, for north pier, 95 feet of pile-pier, connecting the south pier with the shore, and dredging the channel to 12 feet of water.

The cost of work and material, itemized, is as follows:

3,575.64 cubic feet of pine timber, furnished and framed, at 26 cents per cubic foot	$1,007 66
2,340 cubic feet of hemlock timber, furnished and framed, at 24 cents per cubic foot	561 60
112.77 cords of stone, furnished in pier, at $13.75 per cord	1,550 58
17,064 pounds of iron drift and screw bolts, washers, strap-irons, and spikes, at an average cost of 4.29 cents per pound	732 82
3,176 linear feet oak piles, furnished, at 10 cents per foot	317 60
660.273 cubic feet oak, furnished and framed, at 38 cents per cubic foot	250 89
60 cords of slabs, furnished in pier, at $1.50 per cord	90 00
Driving oak piles, 1,751 linear feet, at 22 cents per foot	385 22
Dredging, 33.15 days, at $94.50 per day	3,132 67
Removing 750 running feet old slab pier, at $1 per foot	750 00
Removing 41 cubic yards slabs, below water, at 75 cents per yard	30 75
Labor	30 86
Superintendence	1,214 87
Advertising	20 70
Total	10,076 22
Amount on hand July 1, 1871	$10,085 04
Less amount expended during fiscal year to date	10,076 22
Amount unexpended June 13, 1872	8 82

The Government piers are in good repair. The interior slab revetments are fast rotting away, and the sand drifts over into the channel from the dunes on the south side.

A very narrow channel, but of a depth not less than 8½ feet, is, however, maintained.

B 5.

WHITE RIVER, MICHIGAN.

The superstructure of north pier has been completed, over 64 feet of piling driven before the close of the last annual report, and carried on a further distance of 96 feet over piles driven during the fiscal year included in the present report. Beyond this completed superstructure the piling is complete for a section 40 feet square, intended for a pier-head.

On the south side the completed pier has been prolonged 68 feet, beyond which the piles are driven for a further extension of 28 feet. The filling in the piers about the shore-line, where sand came through, was thoroughly overhauled, and there is now less sand in the channel than a year since.

All materials were bought in open market, and the work was done by hired labor.

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The detailed cost was as follows:

3,668 cubic feet pine timber, at 10 cents per cubic foot	$366
8,123 feet board-measure oak timber, at $16 per thousand feet	129
329 hard-wood piles, at an average price of $2.02 per pile	665
Rehandling 85½ cords stone, at $1.50 per cord	128
Furnishing, in pier, 673 cords of brush and slab, at $2 per cord	1,346
Repairs on pile-driver	257
Labor, framing, driving piles, and filling piers	5,608
Repairs on dredging-apparatus	2,715
Superintendence	1,912
Advertising	39
Total	13,170
Amount on hand July 1, 1871	$13,925
Amount received from sale of tug's hull and boiler	350
	14,275
Less amount expended during fiscal year to date of report	13,170
Amount available June 13, 1872	1,104

This harbor has now a depth of water not less than 9 feet. Whe the shore-line intersects the piers, however, the channel is narro owing to the sand which came through the piers during the winter 1870–'71, as heretofore mentioned.

B 6.

MUSKEGON, MICHIGAN.

During the past year a crib 30 feet square has been sunk on no pier-extension, and superstructure built over this and the two cribs n interior, one 30 feet square, and the other 32 feet by 20 feet, sunk the years 1870 and 1869 respectively. Stone to fully ballast this p was furnished on contract of E. W. Diercks, dated September 4, 18

A heavy storm late in the fall made a breach through the old sou slab pier where it joins the Government pier. This was closed imme ately by building 34 feet of pile-pier. Excepting stone, the materi were bought in open market. All work was done by hired labor.

The expenditure in detail was as follows:

2,688 feet, board-measure, pine plank, at $15 per thousand feet	$40
41 piles, at an average price of $1.51 per pile	61
229.66 cords of stone furnished in pier, at $12.34 per cord	2,834
8,096 pounds of iron drift-bolts, at 3.9 cents per pound	315
30 cords of slabs, at 70 cents per cord	21
Driving piles	138
Labor framing and moving stone	1,054
Repairs on dredging-apparatus	4,944
Superintendence	1,809
Advertising	45
Total	11,265
Amount on hand July 1, 1871	$13,513
Less amount expended during fiscal year to date of report	11,265
Amount available June 13, 1872	2,247

During the past winter the north pier-head pitched badly to the nor west, and needs releveling. Otherwise, excepting the old slab pie the harbor is in good condition.

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B 7.

GRAND HAVEN, MICHIGAN.

Under the contract of T. Stewart White, dated August 27, 1870, about 460 feet of repairs were completed, from the point reached at the time of the last report, to the work of 1869.

The detailed cost of the work was as follows:

275 feet white-oak piles, at 15 cents per foot	$1,241 25
72,996 feet, board-measure, pine timber, at $25 per thousand feet	1,824 90
5,356 feet, board-measure, oak timber, at $45 per thousand feet	241 05
884 11/12 cords of slabs, at $2.25 per cord	1,989 18
Driving piles, 3,641, at 20 cents per foot	728 20
Tearing away 159 feet old work, at $1.75 per foot	278 25
Removing 16 cords stone, at $3 per cord	48 00
Iron bolts	17 57
Heading 916 bolts, at 2½ cents per bolt	22 90
Superintendence	553 50
Advertising	106 37
Transportation	58
Total cost	7,051 75
Amount on hand July 1, 1871	$7,051 75
Amount expended to June 1, 1872	7,051 75
Amount on hand June 1, 1872	0,000 00

The entire amount available having been exhausted, nothing has been done this season. The old work is in about the same condition as heretofore reported, with the exception of the inner revetment, which is rapidly going to pieces.

B 8.

BLACK LAKE, MICHIGAN.

Six hundred and forty feet of pile-revetment were completed, 320 feet on each side of the cut inward from the ends of the old piers. The superstructure of 100 feet of crib-work, at the inner end of the south pier, which was begun in 1870, was finished, and also the pier-head crib to the north pier. A protection of piles was constructed around the north pier-head.

The following is the detailed cost of the whole work:

10,346 linear feet white-oak piles, at 13 cents per foot	$1,409 98
1,484 cubic feet pine timber, furnished, framed, bolted, and put in place, at 27 cents per cubic foot	1,038 96
1,456 cubic feet pine timber, bolted and put in place, at 10 cents per cubic foot	145 60
240 cubic feet pine timber, at 16⅔ cents per cubic foot	40 00
770 linear feet oak timber, 4 by 8 inches, at 21 cents per foot	154 98
916 linear feet oak timber, 10 by 12 inches, at 31 cents per foot	283 96
640 feet, board-measure, pine plank, at $16 per thousand feet	7 20
140.73 cords stone, at $9.75 per cord	982 11
332.5 cords slabs, at $3.25 per cord	1,080 62
7,103 pounds drift-bolts, at 3¾ cents per pound	266 38
1,990 pounds drift-bolts, at 3 cents per pound	59 40
1,945 pounds screw-bolts, at 5¼ cents per pound	101 47
891.7 pounds screw-bolts, at 4¾ cents per pound	39 51

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48 iron spikes, 8 inches, at 5 cents per spike	$2 4
89 pounds boat-spikes, at 5¼ cents per pound	4 6
2,098 cubic feet pine timber, framed, bolted, and put in place, at 14½ cents per foot	304 2
Iron straps for pier-heads	30 9
Superintendence	814 7
Advertising	35 7
Transportation	14 7
Labor	7 1
Driving piles, 6,189 feet, at 22 cents per foot	1,361 5
Total cost	8,186 9
Amount on hand July 1, 1871	$8,186
Amount expended to June 1, 1872	8,186 9
Amount on hand June 1, 1872	0,000

Some damage has been done by the sea and by ice to the head of th north pier, but no expensive repairs are necessary. In other parts th work remains in good condition.

B 9.

SAUGATUCK, MICHIGAN.

The work of protecting the slab pier on the south side of the rive under contract of F. L. Tebel, has proceeded very slowly. But 365 fe have been finished. Some refilling of the old revetment, built in 187 was found necessary.

The following is the detailed cost of the work:

6,342 linear feet hemlock piles, at 8 cents per foot	$507
4,378 linear feet white-oak piles, at 12 cents per foot	525
2,668 linear feet 12 by 12 pine timber, furnished framed and bolted in place, at 25 cents per linear foot	667
405 linear feet 4 by 8 inches oak timber, furnished framed and bolted in place, at 32 cents per linear foot	129
456 linear feet 10 by 12 inches oak timber, furnished framed and bolted in place, at 29 cents per linear foot	132
105.25 cords of stone, at $10 per cord	1,052
319 cords of slabs, at $2.50 per cord	797
5,426 pounds of screw-bolts and washers, at 4.9 cents per pound	265
11,697 pounds of drift-bolts and washers, at 3.9 cents per pound	456
Labor	875
Superintendence	1,159
Advertising	44
Transportation	61
Sundries for building bolt-shed	4
Sundries for dredge	161
Tug-boiler	2,000
Driving 390 piles, at $2 each	780
Removing 220 cords of slabs, at $1.25 per cord	277
Total	9,927
Amount on hand July 1, 1871	$14,736
Amount expended to June 13, 1872	9,927
Amount available June 13, 1872	4,808

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The contractor has commenced work again, and expects to finish it as far as the shore-line. Some refilling is necessary, but with this exception the work is in good condition.

B 10.

SOUTH HAVEN, MICHIGAN.

Under the contract of George Hannahs, three cribs, 50 by 32 feet in plan, were sunk, one on the south and two on the north pier. It was found necessary to dredge, and in the month of September the United States tug and dredge were sent to this harbor. Owing to the lateness of the season but little work could be done. The dredge was drawn out at the harbor and repaired during the winter. The work of dredging has again commenced.

The following is the detailed cost of the work:

15,334 cubic feet hemlock timber, furnished framed, bolted, and put in place, at 29½ cents per foot	$4,538 28
1,818 linear feet pine timber, furnished framed, bolted, and put in place, at 29½ cents per foot	536 31
349.019 cords of stone, at $11 per cord	3,839 21
32,942.16 pounds drift-bolts, at 3¾ cents per pound	1,235 33
4,254.42 pounds screw-bolts, at 5½ cents per pound	233 99
984 pounds washers, at 4¼ cents per pound	41 99
520 pounds screw-bolts, at 6¾ cents per pound	35 10
225 pounds washers, at 5 cents per pound	11 25
Advertising	52 80
Straps for pier-head	42 05
Towing United States dredge	275 00
Sundries and work on tug and repairs of dredge	748 20
Fuel for United States tug	74 00
Transportation	72 38
Superintendence	1,129 20
Labor	2,289 61
Total cost	15,154 75
Amount on hand July 1, 1871	$16,476 00
Amount expended to June 13, 1872	15,154 75
Amount on hand June 13, 1872	1,321 25

A large amount of stone was lost from the new cribs, and some refilling may be necessary. The outer crib on the north side lost so much stone that it was moved entirely out of its position, and, finally, losing all stone, it was necessary to secure it with chains for the winter. It has not been replaced, and is in bad condition.

B 11.

SAINT JOSEPH, MICHIGAN.

The south pier has been extended 416 feet by contractor R. A. Conolly, and some crib-work put in, at slight cost, to make good the connection between the south pier and the shore.

The following is the detailed cost of the work:

8,236.5 linear feet white-oak piles, at 14 cents per foot	$1,153 11
9,660 linear feet white-oak piles, at 16 cents per foot	1,545 60

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6,157.2 feet, board-measure, oak timber, furnished framed, bolted, and put in place, at $39 per thousand	$240
59,370 feet, board-measure, pine timber, furnished framed, bolted, and put in place, at $27.60 per thousand	1,638
277.84 linear feet oak timber, 10 by 12 inches, furnished framed, bolted, and put in place, at 45 cents per foot	125
277.84 linear feet oak timber, 4 by 8 inches, furnished framed, bolted, and put in place, at 45 cents per foot	125
2,677½ linear feet pine timber, 12 by 12 inches, furnished framed, bolted, and put in place, at 40 cents per foot	1,070
4,399 pounds drift-bolts, at 3.9 cents per pound	171
1,085 pounds drift-bolts, at 4¼ cents per pound	46
1,414 pounds screw-bolts, at 8½ cents per pound	120
4,581 pounds screw-bolts, at 4.9 cents per pound	224
960¾ cords slabs, at $2.83 per cord	2,718
470.56 cords slabs, at $3.25 per cord	1,529
139.87 cords stone, at $12 per cord	1,678
133¾ cords stone, at $10.45 per cord	1,397
Driving 3,231 linear feet piles, at 22 cents per foot	710
Driving 4,173¾ linear feet piles, at 26 cents per foot	1,085
Spikes	20
Sundries for repairs of pier	115
Machinery for tug	2,078
Advertising	38
Transportation	2
Labor	44
Superintendence	1,748
Total cost	19,628
Amount on hand July 1, 1871	$19,931
Amount expended to June 13, 1872	19,628
Amount on hand June 13, 1872	302

There is considerable refilling necessary on both the north and sou piers, and some slight repairs.

APPENDIX *b*.

REPORT OF CAPTAIN S. M. MANSFIELD, CORPS OF ENG NEERS, JUNE 13 TO 30, 1872.

UNITED STATES ENGINEER OFFICE,
Detroit, Michigan, August 28, 1872.

GENERAL: I have the honor to submit the following report of oper tions of the work carried on under my charge from the date of t report of my predecessor, June 16, 1872, to June 30, 1872.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Captain of Engineers, Brevet Lieutenant-Colonel, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army.

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b 1.

FRANKFORT HARBOR, MICHIGAN.

Amount on hand of appropriation approved March 3, 1871	$1 65
Amount of appropriation approved June 10, 1872	10,000 00
Amount on hand July 1, 1872	10,001 65

Part of this amount will be applied this fall to a south pier-crib extension of 65 feet, leaving the piers even, and the balance reserved until spring for dredging, should the channel block up during the winter, as may be expected from past experience. On the accompanying tracing this crib is shown in blue. The importance of making a harbor of refuge for the large fleet constantly passing this point has been fully considered in previous reports, and needs no further discussion.

The local interests, inconsiderable at the time the harbor was first proposed, bid fair to attain an unlooked-for importance; especially is this the case with the manufacture of lumber and iron.

To extend the piers, as designed since 1869, will require, under future appropriations, a further addition of 264 feet to each, shown in red, and will cost the estimate of last year, $56,000, less the present appropriation, $10,000, or $46,000, which can be profitably expended during the fiscal year ending June 30, 1874.

Statement of vessels entered and cleared at Frankfort Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes, during the year 1871.

ENTERED.

Vessels, number	112	Butter, firkins	25
Tonnage, tons	12,830	Butter, pounds	10,700
Crews, number	701	Eggs, dozen	400
Oats, bushels	7,850	Apples, barrels	9
Corn, bushels	300	Stone, cords	603
Rye, bushels	14	Coal, tons	15
Hay, tons	144	Lime, barrels	21
Flour, barrels	1,555	Salt, barrels	20
Feed, tons	112	Brick, thousand	103
Pork, barrels	159	Iron ore, tons	6,884
Beef, barrels	24	Merchandise, packages	956

CLEARED.

Vessels, number	107	Fence-posts, number	1,000
Tonnage, tons	2,425	Bark, cords	502
Crews, number	679	Wood, cords	255
Lumber, thousand feet	2,932	Iron, tons	1,821
Timber, thousand feet	804	Fish, kegs	23
Telegraph-poles, number	250	Merchandise, packages	280
Railroad-ties, number	4,037		

b 2.

MANISTEE HARBOR, MICHIGAN.

The north superstructure over cribs sunk last fall by R. P. Thurber was continued by hired labor, at a cost of $1,715.62, but not completed down to June 30, 1872; shown in the accompanying tracing in blue.

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Amount on hand of appropriation approved March 3, 1871	$2,714 57
Amount of appropriation approved June 10, 1872	10,000 00
	12,714 57
Less amount expended in fiscal year, after June 13, 1872	1,715 62
Amount on hand July 1, 1872	10,998 95

This amount will be applied, after making necessary repairs and com pleting north superstructure, to revetting 600 feet of north-channe shore; shown in blue.

To complete the inside work of this harbor, as heretofore designed will require, under future appropriations, to be constructed 280 feet o revetment to north shore, and 580 feet to south shore; the latter, afte dredging 13,046 cubic yards of earth and slabs from the point, t straighten and widen the channel; all shown in red.

The estimate for north revetment, last year, was $16.25 per foot, o $13,812.50, of which, $10,000 has been appropriated. At the same rat the south revetment will cost $9,425; the dredging will cost $6,523 There will be necessary, therefore, $19,760.50, which can be profitabl expended during the fiscal year ending June 30, 1874.

Statement of vessels entered and cleared at Manistee Harbor, Michigan showing the number of vessels, tonnage, crews, and cargoes, during th year 1871.

ENTERED.

Vessels, number	1,283	Eggs, dozen	13
Tonnage, tons	211,684	Apples, barrels	
Crews, number	10,046	Potatoes, bushels	2,22
Oats, bushels	84,635	Stone, cords	14
Corn, bushels	9,465	Coal, tons	60
Hay, tons	1,435	Lime, barrels	2
Hay, bales	61	Salt, barrels	19
Flour, barrels	5,490	Brick, thousand	14
Feed, tons	1,327	Pig-iron, tons	6
Pork, barrels	2,174	Live stock, head	1,15
Beef, barrels	850	Merchandise, tons	13
Butter, firkins	10	Merchandise, packages	18,92
Butter, pounds	2,000		

CLEARED.

Vessels, number	1,287	Wood, cords	61
Tonnage, tons	215,123	Wooden bowls, racks	37
Crews, number	10,089	Apples, barrels	5
Lumber, thousand feet	165,794	Potatoes, bushels	45
Lath, thousand	95	Fish, barrels	4
Shingles, thousand	2,490	Fish, half-barrels	15
Pickets, thousand	54	Fish, packages	31
Timber, thousand feet	840	Merchandise, packages	5,16
Railroad-ties, number	20,000	Maple sugar, pounds	8,00
Fence-posts, number	3,600		

b 3.

PÈRE MARQUETTE HARBOR, MICHIGAN.

Amount on hand of appropriation approved March 3, 1871	$0 13
Amount of appropriation approved June 10, 1872	10,000 00
Amount on hand July 1, 1872	10,000 13

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This amount will be applied to widening the channel, by removing a part of the old slab pier from the south side, and revetting opposite the portion removed.

The whole of this work has been previously estimated to cost $35,440, of which $10,000 has been appropriated, leaving $25,440 necessary for its completion.

An examination of the accompanying tracing will show a bad bar formed west of the piers. An extension of the piers, beyond this bar, together with dredging the channel, would benefit very much the shipping interests, now rapidly developing, and likely to continue large.

To extend the piers 250 feet each, to attain 12 feet water, will require ten 50-feet cribs, costing $4,000 each, or $40,000. These amounts ($65,440) can be profitably expended during the fiscal year ending June 30, 1874.

Statement of vessels entered and cleared at Père Marquette Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes, during the year 1871.

ENTERED.

Vessels, number	423	Hay, tons	577
Tonnage, tons	52,956	Flour, barrels	2,143
Crews, number	2,588	Feed, tons	64
Oats, bushels	18,080	Meal, pounds	600
Corn, bushels	8,998	Pork, barrels	172
Other grain, (not specified)	16,500	Merchandise, packages	14,688

CLEARED.

Vessels, number	423	Timber, thousand feet	815
Tonnage, tons	53,507	Railroad-ties, number	1,200
Crews, number	2,625	Wood, cords	1,234
Lumber, thousand feet	44,996	Shingle, cords	80
Lath, thousand	1,252	Fish, half-barrels	84
Shingles, thousand	3,933	Fish, packages	131
Pickets, thousand	132	Merchandise, packages	125

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b 4.

PENTWATER HARBOR, MICHIGAN.

Amount on hand of appropriation approved March 3, 1871	$8 82
Amount of appropriation approved June 10, 1872	30,000 00
Amount on hand July 1, 1872	30,008 82

The amount asked for last year, $54,780, covered the removal of the old south slab pier and revetment of the channel-way. To this work, the present appropriation, $30,000, is about to be applied. There will be necessary, therefore, to complete the work, $24,780, which can be profitably expended during the fiscal year ending June 30, 1874.

The accompanying sketch shows work under the present appropriation, in blue; under future appropriations, in red.

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Statement of vessels entered and cleared at Pent Water Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes, during the year 1871.

ENTERED.

Vessels, number	312	Butter, firkins	293
Tonnage, tons	26,295	Butter, tub	1
Crews, number	1,631	Butter, pounds	3,200
Oats, bushels	31,400	Eggs, dozen	6,298
Corn, bushels	10,604	Potatoes, bushels	570
Hay, tons	639	Stone, cords	169
Flour, barrels	1,686	Coal, tons	33
Feed, tons	166	Salt, barrels	164
Pork, barrels	522	Brick, thousand	243
Beef, barrels	353	Hides, number	6
Other meats, ton	1	Merchandise, packages	2,330

CLEARED.

Vessels, number	306	Wood, cords	1,552
Tonnage, tons	24,313	Shingle-bolts, cords	332
Crews, number	1,605	Hoops, thousand	95
Lumber, thousand feet	10,058	Wooden bowls, racks	649
Lath, thousand	323	Berries, (not stated,) bushels	20
Shingles, thousand	75,257	Wheat, bushels	97
Pickets, thousand	6	Flour, barrels	4
Telegraph-poles, number	300	Fish, barrels	60
Railroad-ties, number	34,695	Fish, half-barrels	80
Fence-posts, number	14,900	Fish, packages	105
Bark, cords	1,970	Merchandise, packages	535

b 5.

WHITE RIVER HARBOR, MICHIGAN.

The north pier-head has been completed by hired labor, at a cost of $472.80.

Amount on hand of appropriation approved March 3, 1871	$1,104 80
Amount of appropriation approved June 10, 1872	10,000 00
	11,104 80
Less amount expended during fiscal year after June 13, 1872	472 80
Amount on hand July 1, 1872	10,632 00

The present appropriation will be entirely expended in ballasting the piers and dredging the work for which it was intended. To make the piers complete, as originally designed, and as called for in 1870, the south pier should be extended 136 feet, even with the north pier, at a cost of $6,940, which can be profitably expended during the fiscal year ending June 30, 1874.

Statement of vessels entered and cleared at White River Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes during the year 1871.

ENTERED.

Vessels, number	631	Pork, barrels	38
Tonnage, tons	61,363	Beef, barrels	27
Crews, number	3,361	Stone, cords	213
Wheat, bushels	250	Lime, barrels	105
Oats, bushels	38,892	Salt, barrels	155
Corn, bushels	38,419	Brick, thousand	189
Hay, tons	555	Merchandise, packages	5,723
Flour, barrels	975		

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CLEARED.

Vessels, number	635	Railroad-ties, number	61,600
Tonnage, tons	61,529	Bark, cords	2,946
Crews, number	3,360	Wood, cords	2,236
Lumber, thousand feet	44,853	Shingle-bolts, cords	2,628
Lath, thousand	3,309	Hoops, thousand	38
Shingles, thousand	32,340	Hoop-poles, thousand	1,500
Pickets, thousand	32	Potatoes, bushels	450
Timber, thousand feet	70	Merchandise, packages	200

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b 6.

MUSKEGON HARBOR, MICHIGAN.

Unless the work of converting into pile-piers that portion of the old slab piers, shown in the accompanying tracing in blue, proves more difficult than anticipated, the funds on hand, July 1, 1872, $11,688.11, will accomplish all that is at present necessary. The harbor is in excellent condition, and no further appropriation is asked for.

Statement of vessels entered and cleared at Muskegon Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes, during the year 1871.

ENTERED.

Vessels, number	2,461	Apples, barrels	110
Tonnage, tons	422,255	Potatoes, bushels	520
Crews, number	18,884	Coal, tons	22
Wheat, bushels	9,000	Lime, barrels	220
Oats, bushels	46,525	Brick, thousand	5,434
Corn, bushels	24,327	Pig-iron, tons	15
Hay, tons	533	Railroad-iron, bars	179
Butter, firkins	198	Live stock, head	20
Butter, pounds	5,400	Merchandise, packages	2,069
Eggs, dozen	2,300		

CLEARED.

Vessels, number	2,491	Staves, thousand	140
Tonnage, tons	430,154	Pickets, thousand	1,358
Crews, number	19,496	Timber, thousand feet	320
Lumber, thousand feet	277,842	Railroad-ties, number	75,400
Lath, thousand	41,752	Bark, cords	525
Shingles, thousand	7,020	Wood, cords	1,680

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b 7.

GRAND HAVEN HARBOR, MICHIGAN.

Amount on hand of appropriation approved March 3, 1871	
Amount of appropriation approved June 10, 1872	$15,000 00
Less amount expended during fiscal year after June 13, 1872	2 75
Amount on hand July 1, 1872	14,997 25

Under the present appropriation the reballasting and repairing of the outer work proposed by my predecessor, Major F. U. Farquhar, will be completed, and 600 feet of pile-revetment built, (inward from the work of last season.) The latter is designed to replace the existing revet-

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ment, which is seriously damaged. A pier-head, to cost $7,000; a north pier, to cost $200,000; and the repairing or replacing of the inner revetment throughout its entire length, to cost $36,000, were recommended by Major Farquhar, in his report for 1871. These recommendations are renewed. The funds required to complete this harbor are as follows:

For a north pier	$200,00
For a pier-head crib on the south pier	7,00
For finishing the repairing or replacing of inner revetment	26,30
Total amount required	533,30

Of this, $100,000 can be advantageously expended during the fiscal year ending June 30, 1874.

On the sketch the work to be done with funds available is shown in blue, and all proposed work in red.

Statement of vessels entered and cleared at Grand Haven Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes, during the year 1871.

ENTERED.

Vessels, number	1,124	Butter, firkins	2
Tonnage, tons	403,174	Butter, tubs	
Crews, number	12,227	Butter, pounds	4,3
Wheat, bushels	20,101	Eggs, dozen	7,8
Oats, bushels	47,294	Lard, tierces	15,6
Corn, bushels	30,204	Apples, barrels	7
Rye, bushels	4,222	Cranberries, barrels	5
Barley, bushels	15,074	Potatoes, bushels	4,2
Other grain, bushels	1,482	Stone, cords	5
Other grain, barrels	418	Coal, tons	1,6
Hay, tons	315	Lime, barrels	9,9
Hay, bales	627	Salt, barrels	10,7
Hops, bales	3,065	Brick, thousand	73,6
Flour, barrels	355,888	Pig-iron, tons	
Feed, tons	4,407	Railroad-iron, bars	
Meal, pounds	272,000	Railroad-iron, tons	1,4
Wool, bales	3,639	Live stock, head	1,5
Pork, barrels	36,800	Hides, number	5,6
Beef, tierces	1,417	Merchandise, packages	98,1
Other meats, tons	3,376		

CLEARED.

Vessels, number	1,123	Strawberries, bushels	1
Tonnage, tons	396,391	Wheat, bushels	17,4
Crews, number	11,871	Grain, (not specified,) bushels	3
Lumber, thousand feet	88,167	Flour, barrels	6
Lath, thousand	1,494	Potatoes, bushels	8
Shingles, thousand	20,316	Plaster-rock, tons	7
Staves, thousand	1,302	Plaster-rock, ground, barrels	7,4
Pickets, thousand	69	Stucco, barrels	7
Timber, thousand feet	1,001	Salt, barrels	4,4
Railroad-ties, number	24,026	Iron, tons	9
Bark, cords	1,846	Railroad-iron, tons	1
Wood, cords	4,279	Railroad-iron, bars	3,7
Hoops, thousand	1,320	Fish, barrels	1,4
Hoop-poles, thousand	400	Fish, boxes	1,8
Heading, barrels	445	Fish, half-barrels	2
Apples, barrels	32,827	Fish, packages	7,6
Peaches, bushels	12,000	Merchandise, packages	228,8
Fruit, (not specified,) bushels	1,454	Live stock, head	3
Dried fruit, bushels	2,281		

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b 8.

BLACK LAKE HARBOR, MICHIGAN.

Amount on hand of appropriation approved March 3, 1871	
Amount of appropriation approved June 10, 1872	$10,000
Amount on hand July 1, 1872	10,000

During the present season the channel will be dredged out by the United States dredge, and 400 feet more of the revetment of the cut finished. After this is done only about 450 feet of revetment are requisite to complete the improvement, at least for the present.

The estimate furnished by my predecessor in the report of 1871, for this work, is deemed insufficient. No allowance was made for dredging, since found imperative.

The current from Black Lake is so sluggish that the use of a dredge from time to time will be indispensable. No further extension of the piers is immediately necessary. I would recommend the following appropriations:

To complete the revetment of the cut	$7,000
For dredging and contingencies	5,000
Total	12,000

All of this can be advantageously expended during the fiscal year ending June 30, 1874.

Statement of vessels entered and cleared at Black Lake Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes, during the year 1871.

ENTERED.

Vessels, number	255	Meal, pounds	2,000
Tonnage, tons	15,379	Coal, tons	27
Crews, number	1,155	Lime, barrels	611
Oats, bushels	120	Salt, barrels	645
Corn, bushels	1,400	Pig-iron, tons	1,000
Hay, tons	30	Hides, number	2,583
Hay, bales	4	Merchandise, packages	5,155

CLEARED.

Vessels, number	260	Wooden bowls, racks	570
Tonnage, tons	15,514	Heading, barrels	828
Crews, number	1,190	Apples, bushels	108
Lumber, thousand feet	2,038	Barley, bushels	140
Shingles, thousand	628	Flour, barrels	1,345
Staves, thousand	2,369	Potatoes, bushels	76
Railroad-ties, number	102,050	Plastering-hair, pounds	36,800
Bark, cords	2,538	Merchandise, packages	1,793
Wood, cords	4,178	Leather, pounds	39,900

b 9.

SAUGATUCK HARBOR, MICHIGAN.

The work of revetting with piles the south slab pier has been continued under the contract with F. L. Tebel, at an expenditure of $625.62, itemized as follows:

For 25 linear feet 4 by 8 inches oak timber, furnished and used, at 32 cents per foot	$8 00

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For 24 linear feet 10 by 12 inches oak timber, furnished and used, at 29 cents per foot	$6
For 1,001½ linear feet white-oak piles, furnished and used, at 12 cents per foot	120
For 1,831 linear feet hemlock piles, furnished and used, at 8 cents per foot	146
For 112 piles driven, at $2 per pile	224
Superintendence	120
Total	625

But not completed down to June 30, 1872, as shown in the accom panying tracing.

Amount on hand of appropriation approved March 3, 1871	$4,808
Amount of appropriation approved June 10, 1872	15,000
	19,808
Less amount expended in fiscal year after June 13, 1872	625
Amount on hand July 1, 1872	19,183

With funds available the protection of the slab pier on the south si will be completed. This work has been found much more expensi than was at first supposed, and, owing to this fact, nothing has be done on the north side.

I would renew the recommendations (see report of Chief of Enginee 1871) for a north pier and revetment, to cost $59,300.98. Of this su $25,000 could be advantageously expended during the fiscal year endi June 30, 1874.

Statement of vessels entered and cleared at Saugatuck Harbor, Michig showing the number of vessels, tonnage, crews, and cargoes, during year 1871.

ENTERED.

Vessels, number	558	Coal, tons	
Tonnage, tons	71,638	Lime, barrels	
Crews, number	3,897	Salt, barrels	
Grain, (not specified,) bushels	12,970	Brick, thousand	
Hay, tons	105	Pig-iron, tons	
Hay, bales	82	Railroad-iron, bars	
Flour, barrels	378	Hides, number	18,
Feed, tons	20	Merchandise, packages	5,
Pork, barrels	118		

CLEARED.

Vessels, number	571	Wood, cords	7,
Tonnage, tons	72,069	Headings, barrels	3,
Crews, number	3,440	Apples, bushels	2,
Lumber, thousand feet	27,495	Berries, (not specified,) bushels	
Lath, thousand	1,712	Flour, barrels	
Shingles, thousand	24,696	Plastering-hair, pounds	37,
Staves, thousand	740	Fish, packages	1,
Pickets, number	365	Merchandise, packages	
Railroad-ties, number	37,759	Leather, pounds	609,
Bark, cords	563		

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b 10.

SOUTH HAVEN HARBOR, MICHIGAN.

The work of dredging this harbor by hired labor, in connection with the United States dredge, has been continued, at a cost of $1,451.70, and nearly completed.

Amount on hand of appropriation approved March 3, 1871	$1,321 25
Amount of appropriation approved June 10, 1872	12,000 00
	13,321 25
Less amount expended in fiscal year after June 13, 1872	1,451 70
Amount on hand July 1872	11,869 55

It is proposed to replace a crib that was removed from the north pier during the winter, and to build and sink one other in extension of the same pier.

The recommendations made in the report of the Chief of Engineers for 1871, by Major Farquhar, for dredging and removing slab pier, to cost $32,000, and for a revetment, to cost $12,138.33, are renewed.

An extension of 400 feet to each pier was formerly recommended. (See report of Chief of Engineers for 1869 and for 1870.)

After the work now laid out is finished, there will remain, of this, 300 feet for the south and 250 feet for the north pier. The work should be carried out for these distances, at least, to prevent the formation of a very troublesome outer bar every fall. Fifty-five thousand dollars is necessary to do this. The increase over and above the former estimate ($54,000 for 800 feet) is due to the fact that larger and more expensive cribs are now used at this point.

The dredging done at this harbor during the present year will not materially change the original estimate, because all work of this description can secure but a temporary advantage until the channel-way is widened.

To complete this harbor there will be needed the following:

For pier-extension	$55,000 00
For dredging, and removing slabs	32,000 00
For building revetment	12,138 33
Total	99,138 33

Fifty thousand dollars can be advantageously expended during the fiscal year ending June 30, 1874.

Statement of vessels entered and cleared at South Haven Harbor, Michigan, showing the number of vessels, tonnage, crews, and cargoes, during the year 1871.

ENTERED.

Vessels, number	358	Potatoes, barrels	30
Tonnage, tons	22,263	Stone, cords	239
Crews, number	1,468	Coal, tons	21
Wheat, bushels	130	Salt, barrels	245
Oats, bushels	300	Brick, thousand	4,020
Corn, bushels	2,200	Pig-iron, tons	58
Hay, tons	26	Merchandise, packages	1,100
Flour, barrels	250		

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CLEARED.

Vessels, number	365	Railroad-ties, number	4,5
Tonnage, tons	23,610	Bark, cords	8,5
Crews, number	1,551	Wood, cords	4,8
Lumber, thousand feet	4,928	Shingle-bolts, cords	
Lath, thousand	10	Apples, bushels	1,3
Staves, thousand	98	Peaches, bushels	1,5
Timber, thousand feet	1,365	Merchandise, packages	

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b 11.

SAINT JOSEPH HARBOR, MICHIGAN.

Repairs have been put upon the north pier, at a cost of $143.55, v

Superintendence	$120
Labor	20
Freight	2
Total	143

and are still going on.

Amount on hand, of appropriation approved March 3, 1871	$30
Amount of appropriation approved June 10, 1872	3,00
	3,30
Less amount expended in fiscal year after June 13, 1872	14
Amount on hand July 1, 1872	3,15

This money will be expended this year in repairs and filling with st both north and south piers.

No further improvement is deemed necessary to meet all demands commerce at this point.

No appropriation is asked.

Statement of vessels entered and cleared at Saint Joseph Harbor, Michig showing the number of vessels, tonnage, crews, and cargoes, during year 1871.

ENTERED.

Vessels, number	575	Stone, cords	
Tonnage, tons	122,606	Coal, tons	
Crews, number	6,512	Lime, barrels	3
Wheat, bushels	500	Salt, barrels	1
Grain, (not specified,) bushels	36,118	Merchandise, packages	41
Flour, barrels	225		

CLEARED.

Vessels, number	590	Apples, bushels	117
Tonnage, tons	122,065	Peaches, bushels	85
Crews, number	6,603	Grapes, bushels	
Lumber, thousand feet	5,670	Fruit, (not specified,) bushels	61
Shingles, thousand	165	Strawberries, bushels	20
Staves, thousand	40	Berries, (not specified,) bushels	7
Railroad-ties, number	2,550	Flour, barrels	
Bark, cords	370	Fish, barrels	4
Wood, cords	2,022	Merchandise, packages	13

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APPENDIX C.

ANNUAL REPORT OF MAJOR O. M. POE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Detroit, August 29, 1872.

GENERAL: I have the honor to transmit herewith my annual reports relating to the works of river and harbor improvements, &c., under my charge, for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

O. M. POE,
Major of Engineers, Brevet Brigadier-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army.

C 1.

SAINT MARY'S FALLS CANAL.

Since the close of the last fiscal year further action has been taken for the acquirement of the additional lands necessary for the enlargement of the canal; and, to render the subject complete, a detailed history of this action is given, as follows:

The governor of Michigan, under date of August 12, 1871, was requested to furnish information concerning the progress made in acquiring title to the lands referred to, and, under date of August 15, he furnished the information called for. He stated that efforts were made by the board of control in 1870 for the purchase of such lands as they deemed likely to be wanted for canal purposes. These being unsuccessful, renewed efforts had been made during the season of 1871, but also without success. He further stated that the legislature of 1871 authorized the governor to appoint a commission to determine the value and condemn the lands which might be required, but that, doubts having arisen as to the constitutionality of some of the important provisions of the act, it was submitted to some of the most able and reliable lawyers, the result of which was to lead him to defer action for condemning the lands until the act could be amended in some of its features, which could probably be accomplished during the following winter. That in the mean time all proper efforts would be continued for the purchase of the lands.

The amendment of the act referred to, however, was never effected by the legislature, for the reason, as I understand, that the act in question was adjudged unconstitutional, and that the legislature had no power to so amend it as to provide for vesting title in the United States to the lands required in the manner indicated. This, therefore, terminated all efforts in that direction to accomplish the desired result.

Under date of August 22, 1871, I transmitted to the Chief of Engineers a tracing of a plat showing the Government land on the south side of the State-canal grant, with subdivisions and names of claimants; also, a tracing, on a smaller scale, showing the relation of these claims to the canal enlargement, as well as the history of each claim so far as I had been able to obtain it. The location of this land is in section 6,

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township 47 north, range 1 east, being a portion of a tract granted t the Indians as a reservation, and subsequently yielded by them to th United States. A complete history of these transfers could not b given. A clause in the treaty with the Ottawa and Chippewa Indian dated July 31, 1855, indicates that the right of fishing and encampmer (on lands presumed to include those shown on the tracing) was secure to the Chippewas of Sault Ste. Marie by the treaty of June 16, 182 Reference to this made in article 3 of the treaty first mentioned ind cates that the right was not yielded by the Indians at that time; but was informed that it was yielded soon after, by a special treaty wit the band at Sault Ste. Marie, by which the United States assumed e tire control of the whole tract at the rapids, except a small island in th river. The right of way through this tract was granted by the Unite States to the State of Michigan for the purpose of making a cana the grant including an area 200 feet in width on each side of the cent line of the canal, a total width of 400 feet.

Soon after the settlement of the Indian claims (in 1855 or 1856) diffe ent parties "squatted" upon various portions of the land on the sou side of the "canal grant," either building and living upon their claim or fencing and cultivating them. The claims referred to are six in nu ber. No taxes were ever paid on any of this land. Having been co sidered Government land, it was never assessed.

I recommended the retention of all the lots except the one claimed b Carleton & Bernier, and submitted, for instructions, the question entering upon the lands and dispossessing the claimants.

The above being submitted to the Judge-Advocate-General for h opinion as to the authority of the United States to take possession land claimed by squatters, he expressed the opinion that, if thoug proper, they might be legally dispossessed, and gave the course usual pursued in such cases. The Secretary of War, therefore, requested t Attorney-General to call upon the proper United States marshal to eje all the squatters.

The deputy United States marshal was at the canal during the latt week of September, 1871, for the purpose indicated, and arranged t matter so that the occupants were to vacate their claims whenever call upon to do so. He transfered his authority in the premises to Mr. P. Heichhold, who was to act whenever called upon.

The lands belonging to individuals, and also required in the enlarg ment, were made the subject of a separate report to the Chief of En eers on the 22d of August, 1871. This report contained a history of t progress made in acquiring title from its inception to the date of t report, and showed that the attempts made were failures, as appears letter, before referred to, from the governor of Michigan. It also co tained a request for instructions as to the application or expenditure the $250,000 appropriated March 3, 1871; whether the same should retained entire until a further appropriation be made, and then t whole applied to the construction of the new locks, or whether so mu of it as could be expended in enlarging the prism during the winter devoted to such purpose; and if the latter should be deemed bes that it would be necessary to make a new contract, and the questi was presented whether it should be done after advertising or by arrang ment with the contractors at the prices of their existing contract. Th latter was recommended, in view of the great annoyance and possib detriment to the work which would arise from having two sets of co tractors at the same time engaged upon the same work and at differe rates.

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It was decided, however, by the Chief of Engineers, in a communication dated August 26, 1871, that the appropriation referred to should be applied as soon as practicable to the construction of the prism of the canal, but that proposals for such additional work should be invited in the usual manner.

The Chief of Engineers, under date of October 2, 1871, requested an estimate of the probable amount required to re-imburse the State of Michigan for sums expended in acquiring land from private individuals for modification of the canal, or for acquisition of the land by the United States under a condemnation act. In reply to request of October 4, 1871, for such information, the governor of Michigan, in a letter dated December 1, informed me that the aggregate amount asked for the additional lands was $14,000. This information was communicated to the Chief of Engineers on the following day, with the statement that to acquire the lands we were driven to one of three measures:

1st. To purchase the land from the owners at any price they might see proper to ask.

2d. The enactment by Congress of a law conferring upon the proper authorities of the United States the right and power to seize and condemn the land needed.

3d. The enactment by Congress of a law authorizing the expenditure of a portion of the appropriation upon lands belonging to the State of Michigan, in which case the State could seize the lands, condemn them, and acquire title.

Of these three, the second was strongly recommended.

The act of Congress approved June 10, 1872, appropriated $300,000 for the work, with a proviso that $15,000 of that sum might be expended in securing the desired right of way over the grounds belonging to private parties at the east end of the canal. Upon being informed of this, I at once took measures to ascertain the price at which each individual owner was willing to sell the portions of the lots required. Proposals have been received accordingly, and indicate that the owners adhere to the prices previously named to the State authorities, which, in the aggregate, reach the sum of $14,000. This sum is largely in excess of the real value of the property, but it is not at all likely that the demands of the owners will ever be diminished.

Upon the basis that only the immediate water-front of all the claims be purchased, in addition to the amount of claim, seventy-eight originally-proposed offers from the owners were also obtained, the total amount of which is $7,050.

These two propositions were submitted to the Chief of Engineers on the 22d of July, 1872, with request for authority to accept one of them, and with the remark that I considered the first one unobjectionable and desirable; but that the second was subject to the objection that it would leave the owners all their right and title up to the channel-bank as it would be after the dredging proposed to be done, in which case they might permit vessels to obstruct the entrance to the new lock, though I thought it would subserve all necessary purposes.

The titles being considerably involved, I, at the same time, requested that application be made to the Attorney-General of the United States to instruct the district-attorney to have the title-papers put into proper shape.

Under date of July 30, the Chief of Engineers instructed me to enter into negotiations for the purchase of the additional lands, with the persons named, in the first proposition referred to; and stated that application would be made for instructions to the United States attorney for

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Michigan to assist me in preparing the title-papers, and in such oth duties connected with the purchase as might seem necessary.

The district-attorney having received the requisite instructions in t premises, the matter is now in his hands; and it is hoped that t preparation of the transfer-papers will be pushed forward as prompt as practicable.

As authorized, an advertisement was published inviting proposals f continuing the enlargement of the canal and building a revetment timber and ballast-stone, under the appropriation of $250,000, approv March 3, 1871.

The proposals were opened on the 10th of October, and were as f lows:

Abstract of bids for continuing the improvement of Saint Mary's Falls Canal, opened a p. m., October 10, 1871, *in accordance with advertisement dated September* 7, 1871.

Bidder's name and residence.	Excavation.		Timber, per cubic foot.	Pine plank, per thousand feet board measure.	Iron bolts, per pound.	Spikes, per pound.	Framing, putting in place, &c., per cubic foot of timber used.	Remarks
	For rocks, per cubic yard.	For gravel, per cubic yard.						
Alanson Dodge, Fulton, N. Y....	$3 50	$1 00	$0 30	$40 00	$0 10	$0 10	$0 10	Nov. 10, 1 Aug. 1, 1
Jas. F. Hayden	3 87	1 08	58½	24 95	5½	6½	17	Nov. 15, 1
Samuel W. Norton								Sept. 1, 1
Charles J. DeGraw, Fulton, N.Y..	3 80	1 00	40	75 00	12	12	15	Nov. 25, 1
Samuel G. Hart, Fulton, N. Y....	4 50	2 50	30	40 00	7	7	40	July 1, 1 Dec. 15, 1 May 15, 1
Cephas C. Barker, Fayetteville, N. Y.								Oct. 16, 1
Wallace W. Williams, Manlius, N. Y.	3 00	60	20	25 00	5	7	10	Sept. 1, 1
O. J. Jennings & Co., Syracuse, N. Y.	3 75	1 50	28	50 00	7	7	28	Dec. 1, 1 June 1, 1
Cephas C. Barker, Fayetteville, N. Y.								Oct. 16, 1
Wallace W. Williams, Manlius, N. Y.	2 40	70	20	25 00	5	7	10	July 1, 1

On the following day the abstract was transmitted to the Chief Engineers, showing that the bids of Barker and Williams, (one for t completion of the contract by September 1, 1872, and the other for t completion of the contract by July 1, 1873,) based upon approximate e timates of quantities, were each lower than the offer of any other bi der, and the second considerably lower than the first.

The Chief of Engineers, October 27, 1871, authorized the acceptan of the second proposal referred to, *i. e.*, for the completion of the co tract by July 1, 1873, and the articles of agreement were entered in accordingly.

The governor of Michigan, president of the State board of contro under date of August 30, 1871, gave notice that, for the purpose repair and improvement, the canal would be closed at 12 m. on the 25 of November, 1871, to remain closed until the 1st day of May, 1872.

February 20, 1872, I informed the governor that the first order of t board of control fixed the dates as above stated, and that subsequentl

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the date of closing was fixed at the 1st of December, but the date of opening was not changed; that the result of this extension of seven days the previous fall was exactly what was feared, namely, the hard-freezing weather came on, and, owing to the low temperature, the contractors were seriously interfered with. In view of this fact, I stated that it seemed but simple justice to the contractors to fix the 20th of May as the date of opening; but as the commerce of Lake Superior would be seriously incommoded by such an extension, I suggested instead thereof, as a partial reparation, that the 10th of May be named as the day of opening. This date was therefore specified.

An application having been received from the contractors for the extension of their contracts of October 20, 1870, and February 9, 1871, to the 1st of July, 1873, it was forwarded to the Chief of Engineers February 24, 1872, with a statement of the condition of the work and the reasons leading to a recommendation that the extension asked for be granted. The extension was granted, but with the understanding that the contractors furnish additional security for the performance of the work, and that the clause contained in the new form of contracts, and embraced in their contract of December 7, 1871, in relation to failure to commence and prosecute the work faithfully, &c., be inserted in the contracts; that should the contractors decline to accede to these terms, and the contracts should at the periods specified for their completion, viz, May 1, 1872, and July 1, 1872, (the contract of October 20, 1870, having been extended to the latter period,) be unfulfilled, to declare the retained percentage forfeited to the United States, and proceed to execute the work by hiring labor and purchasing material in open market, unless it would be more advantageous to re-advertise for proposals. The contracts were extended to July 1, 1873, as authorized, and the additional articles of agreement, with the required bonds, were executed on the 15th of April, 1872.

Immediately upon the receipt of the authority granting this extension I directed that the work upon the new guard-gates be prosecuted with the greatest vigor; that they must be rebuilt in the new position, and that the construction of the outer dam (at section 30, west) would be dispensed with for the winter.

On the 18th of June last I reported that Barker, Williams & Bangs had performed their contract under the appropriation approved July 11, 1870, and that the retained percentage had been paid them and the contract closed; and that the guard-lock had been removed, rebuilt, and paid for.

Seeing that no efficient steps had been taken to put in so much of the coffer-dam required for the work of next winter as is comprised in the wings and through the piers to the channel on each side of the canal, I reminded the contractors, under date of June 19, 1872, of their failure in this respect last year, and gave them warning that any omission would not again be overlooked under *any* circumstances, and expressed a desire that they would take the matter in hand within thirty days and prosecute to completion the work of putting in the wings of the coffer-dam on both sides of the canal, extending each wing from the natural shore along the back side of each pier to the proper point on each, and then through the channel.

The progress of the work during the year was very slow, delays arising at almost every stage. Some of this was due to the fault of the contractors, though they operated at times under the most trying difficulties. The extreme severity of the winter, when the most important work could only be carried on, retarded the progress of the work and

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placed the contractors in an embarrassing condition. The difficulty i keeping the force employed up to the requisite standard for the vigo ous prosecution of operations added to the cause of delay; yet it believed that this difficulty could have been ameliorated to a certa extent by the contractors by a judicious line of action in the emplo ment and payment of the men. The isolated region, however, to whi many men are reluctant to go, furnishes some excuse for the low stan ard of the force during the year.

Operations during July, August, and September, 1871, consisted on in receiving timber to be used in the revetment. The bill of timb furnished the contractors embraced 113,000 cubic feet, which they su let to parties on the river and on the shore of Lake Huron. Only abo one-third of the amount called for was furnished, hardly sufficient build the revetment to the water-line.

In October the contractors organized a small force, and employed clearing the site of the pier, above the water-line, extending this wo eastward to the guard-gates on the south side, and to the basin on t north side. A part of the force was detached in November and set loading and hauling clay for the dam.

The cold weather set in very early, (about November 25,) freezing t clay that had been deposited on the bank of the canal into a solid ma rendering it useless. The canal being closed to navigation December the frame of the dam was placed in position at once.

It had been the design of the contractors to place the dam at secti 30 west. Some dredging was necessary before doing so, to break throu the piers and clear the sites for wing-dams connecting the main da with the shore-line. They failed to get the dredge at the work in ti to do this before December 1, and concluded to place a dam at the in end of the south pier, at the position occupied for the same purpose t previous year.

It was understood that this dam would be only temporary and th the one at section 30 would be put in immediately after.

The contractors did not have sufficient force on the work during t winter to render it possible to fulfill this promise without neglecti other work of greater urgency.

The clay for filling was hauled from the pit, about three-fourths of mile, and used at once; but the weather was so severely cold that t clay froze on the way, and was rendered very unsuitable. The ent month of December was consumed in repairing the dam after succ sive leaks. Besides the leaks through the dam itself, the water pass through crevices in the rock around the ends, and under the bottom the same manner, and in about the same quantity as during the pre ous winter. This had to be removed by pumping. The pumps we set up, and a pump-house built early in January.

The excavation during the winter was, from section 14 westward section 5, completed; and from section 50 eastward to section 74 l uncompleted. The guard-gates and walls were removed during Mar and April, and placed in a new position 700 feet above the old o The revetment was carried above the ordinary water-line, between t guard-gates and the dam, and to within about 4 feet of the water-li between the guard-gates and section 71.

Upon commencing the removal of the dam, May 7, it was found th the top of the dam, for a depth of 2 feet below the water-line or abo 4 feet below the top of the dam, was a solid mass of frozen ear through which the dredge of small power and in bad repair could ma but little headway.

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A practicable opening for the passage of vessels and steamers was made late on the 11th, (a day later than that fixed for the opening of the canal,) and on the morning of the 12th all those in waiting passed through.

Since the opening of navigation a small force has been employed in gravel excavation below section 77. About 5,000 cubic feet of timber have been received.

The operations during the year, to June 30, inclusive, resulted in the excavation of 17,741.16 cubic yards of rock and 26,839.40 cubic yards of gravel. In addition, 57,681.11 cubic feet of revetment, estimated as revetting-wall, was placed in the work, and the guard-gates rebuilt.

A table giving the mean water-stage during each month, and showing the effect of certain winds, and a tracing of a diagram showing the elevation of the water's surface during each day in the year, are transmitted herewith. I also accompany this report with a tracing of a map of the canal, with proposed improvements, which shows the condition of the work at the close of the year.

Under date of June 18, 1872, I was notified that $300,000 had been appropriated by act of Congress approved June 10, 1872, and requested to submit a project of operations thereunder.

Except that portion of it provided for the purchase of the additional lands required in the enlargement of the canal, it is proposed to expend this sum toward the construction of the new lock, the plans for which are nearly completed. The project called for is necessarily delayed pending negotiations for the acquirement of the land, but will be taken in hand as soon as possible and submitted for the action of the Chief of Engineers.

The following shows the financial condition of the improvement at the close of the year, and the amount recommended for the service of the fiscal year ending June 30, 1874:

Amount available July 1, 1871, and under contract	$391,681 59
Amount expended from July 1, 1871, to July 1, 1872	99,469 36
Balance on hand July 1, 1872	292,212 23
Amount appropriated June 10, 1872, not yet under contract	300,000 00
Amount available July 1, 1872	592,212 23
Amount required for the fiscal year ending June 30, 1874	600,000 00

The balance of $292,212.23 on hand July 1, 1872, includes $6,671.86, being aggregate amount of percentage retained from payments made to the contractors from time to time agreeably to the terms of their contracts. The materials already delivered under existing contracts, but not placed in the work, also cover some portion of this balance.

The extent of commerce involved in this improvement is so well known that no statistics of the same are deemed necessary. It embraces the entire traffic by vessels between Lake Superior and the other lakes, and its present magnitude has already attained proportions of a large character, with a rapid and greatly increasing tendency.

The estimated cost of the new lock is $884,977.08. Of this amount the sum of $285,000 has been appropriated, ($15,000 of the last appropriation having been made applicable to the purchase of the additional land required in the enlargement,) leaving, in round numbers, the sum of $600,000 yet to be appropriated. The construction of the new lock will require more than one year's time, but the great advantage to the Government arising from letting the contract for the entire construction at one time, induces me to strongly recommend the appropriation of the entire sum at once, and my estimate of the sum required for the fiscal year 1873–'74 is based upon this.

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Table showing the mean elevation of the surface of the water in the Saint Mary's Falls ship-canal above the datum plane during each month of the year ended June 30, 1872, and the mean elevation during the prevalence of winds from various quarters.

Month.	Mean elevation of water's surface above datum plane.		Mean elevation of water's surface above datum plane during prevalence of winds from west to north, including west and excluding north winds.						Mean elevation of water's surface above the datum plane during prevalence of winds from north to east, including north and excluding east winds.						Mean elevation of water's surface above datum plane during prevalence of winds from east to south, including east and excluding south winds.						Mean elevation of water's surface above datum plane during prevalence of winds from south to west, including south and excluding west winds.					
			Above locks.			Below locks.			Above locks.			Below locks.			Above locks.			Below locks.			Above locks.			Below locks.		
	Above locks. Height.	Below locks. Height.	No. of observations.	Height.	Variations from mean for entire month.	No. of observations.	Height.	Variations from mean for entire month.	No. of observations.	Height.	Variations from mean for entire month.	No. of observations.	Height.	Variations from mean for entire month.	No. of observations.	Height.	Variations from mean for entire month.	No. of observations.	Height.	Variations from mean for entire month.	No. of observations.	Height.	Variations from mean for entire month.	No. of observations.	Height.	Variations from mean for entire month.
1871.																										
July	116.16	98.86	18	116.27	+0.11	18	98.82	−0.04	1	116.37	+0.21	1	98.87	+0.01	4	116.07	−0.09	4	98.94	+0.08	8	115.96	−0.20	7	98.92	+0.06
August	116.08	98.72	13	116.27	+0.19	13	98.74	+0.02	1	116.13	+0.05	1	98.96	+0.24	10	115.89	−0.19	10	98.66	−0.06	6	116.00	−0.08	6	98.77	+0.05
September	116.14	98.40	17	116.28	+0.14	17	98.35	−0.05	.....	.....	.....	.....	.....	.....	6	115.86	−0.28	6	98.44	+0.04	7	116.03	−0.11	7	98.51	+0.11
October	115.94	98.11	10	116.14	+0.20	10	98.16	+0.05	3	116.19	+0.25	3	98.24	+0.13	9	115.67	−0.27	9	97.96	−0.15	9	115.88	−0.06	9	98.15	+0.04
November	115.71	97.57	13	116.00	+0.29	13	97.60	+0.03	4	115.62	−0.09	4	97.82	+0.25	6	115.44	−0.27	6	97.58	+0.01	7	115.47	−0.24	7	97.40	−0.17
December	115.32	98.17	8	115.45	+0.13	8	98.26	+0.09	5	115.42	+0.10	5	97.92	−0.25	11	115.11	−0.21	11	98.02	−0.15	6	115.44	+0.12	7	98.50	+0.18
1872.																										
January	115.08	98.01	11	115.06	−0.02	12	98.08	+0.07	.....	.....	.....	.....	.....	.....	11	115.03	−0.05	12	97.90	−0.11	6	115.20	+0.12	7	98.08	+0.07
February	114.99	97.84	7	115.09	+0.10	7	97.97	+0.13	1	114.85	−0.14	1	97.80	−0.04	12	114.96	−0.03	14	97.77	−0.07	7	114.98	−0.01	7	97.85	+0.01
March	114.76	97.86	13	114.86	+0.10	15	97.91	+0.05	.....	.....	.....	1	97.97	+0.11	8	114.58	−0.16	9	97.79	−0.07	6	114.77	+0.01	6	97.85	−0.01
April	114.71	97.49	8	114.75	+0.04	12	97.63	+0.14	.....	.....	.....	.....	.....	.....	10	114.71	−0.00	14	97.29	−0.20	4	114.63	−0.08	4	97.75	+0.26
May	115.60	97.41	9	115.75	+0.15	12	97.62	+0.21	.....	.....	.....	.....	.....	.....	10	115.41	−0.19	12	97.22	−0.19	7	115.68	+0.08	7	97.40	−0.01
June	115.78	97.76	10	115.89	+0.11	10	97.78	+0.02	.....	.....	.....	.....	.....	.....	14	115.67	−0.11	14	97.75	−0.01	6	115.83	+0.05	6	97.78	+0.02
Mean	115.52	98.02	.....	115.65	+0.13	.....	98.08	+0.06	.....	115.76*	+0.06	.....	98.23†	+0.07	.....	115.37	−0.15	.....	97.94	−0.08	.....	115.49	−0.03	.....	98.08	+0.06

* Variation from mean for July, August, October, November, December, and February.
† Variation from mean for July, August, October, November, December, February, and March.

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C 2.

CHEBOYGAN HARBOR.

The last annual report of operations at this improvement closed with the statement that upon the failure of Charles Fitzsimons, of Chicago, to enter into contract for the required dredging upon the terms of his bid, the work was awarded to Messrs. Carkin & Stickney, the next lowest bidders. They entered into contract accordingly, and on the 3d day of August they commenced operations, and continued them with very little interruption to the 17th of November, at which date 32,000 cubic yards of material had been removed, and the appropriation exhausted; the result attained being a channel from the 9-foot curve outside to the same depth inside the bar of 9 feet in depth, 50 feet in width on the bottom, with side-slopes of 1 to 1½.

The present condition of the work is essentially the same as when completed last fall. Inside the bar the cut has been partially filled by a deposit of sawdust, but the passing tugs have caused much of it to move out. It does not appear to impede the progress of vessels, and the only damage done by it seems to arise from the fact that it considerably increases the amount of material removed by the dredge and paid for. The practice of throwing this and other refuse matter from the mills into the river is reported to be nearly discontinued, and it is hoped will soon be entirely so. No change in the slopes of the cut is perceptible, though many severe gales have swept across the channel. A row of round piles, with booms placed between for the purpose of holding logs for the Duncan Bay mill, have been driven from the shore along the eastern bank of the channel, and the slab dock, on the western side, shown on the chart of 1870, has been almost entirely swept away.

By act of Congress approved June 10, 1872, the sum of $15,000 was appropriated for this improvement. It is proposed to expend this toward making a 12-foot channel across the bar. Instead, however, of following the 9-foot channel of last year, it is proposed to dredge upon a straight line, having its termini coincident with those of the crooked channel. As the whole of the 9-foot channel lies within the limit of the channel as originally proposed, no loss results from this modification, and we will ultimately have a perfectly straight channel, instead of the one proposed of two straight reaches making an angle of 11° with each other.

The experience of the past year leads us to infer that no wash need be provided against, and that the piers originally proposed will never be required, thus greatly reducing the final cost of the improvement. The slopes may be made as abrupt as the dredge will cut them; and as the whole cut will be through shoal water, it will be impossible for a vessel, once in the channel, to get out of it, or to run hard aground. Indeed, the present prospect is so favorable that I am inclined to think it will never be necessary to make the cut more than 100 feet wide on the bottom, or about 120 feet at top instead of 200 feet at top, as originally proposed.

In order to carry on this improvement to advantage, and complete it, and with this end in view, I have very respectfully to urge that the entire amount of the balance of the estimate for dredging be appropriated at the next session of Congress. My estimate of last year was $50,000. Of this, $15,000 has already been appropriated, leaving a balance of $35,000 to be provided.

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Within the year, 40,000,000 feet of lumber and timber have passed ou of Cheboygan River. All the supplies and camp-equipage required i getting this lumber out of the forest are either passed on scows, o hauled over saw-dust roads from Duncan Bay.

In the same way all the supplies needed by the inhabitants of th vicinity are brought in. These inhabitants number over 3,000.

The village of Cheboygan now has a population of over 1,000, and i growing rapidly. It offers great inducements to ship-builders, and mus ultimately become important in connection with that interest. An injury requiring the docking of vessels can only be repaired after the have passed the entire length of either Lake Huron or Lake Michiga The inconvenience and danger attending this are so great that one o the very first results of a sufficient channel into the river will probabl be the establishment of a dock-yard of sufficient capacity to make th necessary repairs in the immediate vicinity of the scene of most of th accidents.

The opening of this river will also give an outlet to vast quantities o the most valuable fuel, rapidly becoming a matter of great importanc

The citizens, with commendable energy, have contributed to the im provement of the river inside the inner end of the improvement by th Government. Their contribution, thus far, amounts to $2,000, and ha been partly expended in dredging-work to the amount of the enti contribution being under contract.

The lack of the requisite data concerning the commercial statistics o the place, I am unable to give them, but in this connection respectfull refer to the last annual report with the remark that the commerce o the port was greater during the last year than the year preceding.

The appropriation of March 3, 1871, (the first for this work,) was	$10,000
Expended during the year ended June 30, 1872	9,990
Balance	9
Appropriated by act of June 10, 1872	15,000
Total available July 1, 1872	15,009
Estimate for fiscal year 1873-'74	35,000

Cheboygan is in the collection-district of Michigan. The neare light-house is Cheboygan, two miles distant from the port.

C 3.

AU SABLE RIVER.

The report of last year stated that contracts had been entered in with Mr. Wm. H. Patten for the work to be done on this improveme under the appropriation of March 3, 1871. The under-water work of t south pier was in very bad condition, through having been left in unfinished state for so long a time; the injury having been caus principally by the impact of rafts, which caught upon it, tearing timbers and otherwise damaging it. This was first aligned and levele and the superstructure then carried up to a height of five timbers (5 fe from the angle outward to the end of the pier. From the angle inwa the superstructure was made only four timbers high.

The contractor gave much trouble, having insufficient means to car on such a work, as well as being of such habits as to unfit him f properly meeting and overcoming difficulties. After furnishing all t lumber and iron, and doing a considerable portion of the work, became evident that he was either unable or unwilling to supply t

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ballast-stone required for filling the cribs, in consequence of which, upon the expiration of the time named in his contract for the completion of the work, I declined to recommend an extension and declared the contract forfeited. Although this was as late as the 1st of December, I bought in open market a sufficient amount of ballast-stone to make the work secure for the winter, at $8.50 per cord delivered in the work, or at 8 cents per cord less than the price named in the contract. There was no time during the preceding two months when the contractor could not have done the same thing, a fact of which I duly informed him, even going so far as to name the parties willing to deliver the stone. In fact, owing to the lateness of the season when I ordered the stone, I was compelled to pay a higher price than the contractor would have had to pay in September. The most unaccountable thing in connection with the whole matter is the fact that the contractor had in his power to make more on the delivery of the stone than any other part of the contract, it only requiring that he should give the order for the delivery of the stone, yet for some reason unknown to me he failed to do so.

As already remarked, at so late a date as the 1st of December, I bought so much stone as seemed absolutely necessary at $8.50 per cord, or 8 cents less than the price named in his contract, and the remainder of the stone required is now being delivered at $7.75 per cord or 83 cents per cord less than he was to get.

Declaring the contract forfeited carried with it the forfeiture of the 10 per cent. retained from payments under the contract, but this punished him but little, as he had nothing to lose, but it came hard upon the persons to whom he was in debt for materials or labor, and who necessarily lose the amount due them.

The entire amount of stone purchased last fall in open market was 90 cords, which probably saved the work during the winter, as, being all put into the outer end of the pier, it gave it the strength requisite to withstand the heavy jams of ice which came against it.

The last vessel which delivered stone last fall accidentally got crosswise in the channel and injured both piers, crushing and lifting the timbers so badly that I deemed it necessary to have them repaired at once, and it was done. The work stood the winter remarkably well, and except some settling toward the outer end of the south pier, it is in as good condition as when the winter set in.

By referring to the chart of the harbor, transmitted herewith, it will be seen that the 10 foot curve is now distant from the outer end of the piers 420 feet, an increase of 280 feet during the year. This is largely in excess of the increase in former years, and makes a much less hopeful exhibit for the future of the improvement.

Mr. H. G. Rothwell, the agent in local charge, attributes this to the fact that cuts have been made across points in the river above, the scouring effect being very considerable, and the result being the deposit of the material thus dislodged upon the bar at the head of the piers. This effect he thinks has been increased by using the currents of the river in a similar manner to scour out mill-ponds and boom-cuts, and estimates the total amount of material thus removed and redeposited, at an aggregate of 161,065 cubic yards of sand; being in detail as follows: in cut made by Mr. Brackenridge across point, 97,777 cubic yards; by same person in dredging a bend in the river, 31,288 cubic yards; in boom-cuts of Messrs. Backers & Bros., 32,000 cubic yards. These are, he says, approximate figures only, but he considers them far below the actual amount, and that the effect has been to shorten the life of the present harbor at least five years.

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Under the appropriation approved June 10, 1872, it is proposed to extend the north pier (except the superstructure) a distance of from 150 to 200 feet, with the hope of throwing the current more to the eastward, and, by its scouring action, improving the condition of the bar along the line where the best water is now found. I am constrained to say that the sanguine expectations concerning the value of this improvement, originating in the excellent showing of the previous year, have not been realized, and I am somewhat at a loss what to recommend for the future. The proposed extension of the north pier is, at best, an experiment, and may result only in further illustrating the never-ending operation of the pier-extension system. If the action should not prove to be more favorable than during the last twelve months, it would be cheaper to dredge a channel across the bar, annually, after the winter and spring freshets have done their work, than to further extend the piers, and I make my estimate with this possibility in view.

I instructed the local agent to extend his surveys of this season sufficiently far outward to determine whether or not a bar of sand, reported to exist off the mouth of the harbor, was actually there. It was found at a distance of about a mile from the outer end of the piers, with a maximum depth of 18 feet of water, and on the greater portion of it only 13 feet.

The general depth of water inside this bar is from 3½ to 4½ fathoms. This bar is not well defined on the lake survey published charts, and is, I fear, in process of formation. I will examine further into this matter, and make it the subject of a special report.

The importance of the lumbering interests of this port is annually increasing, and of all the points on Lake Huron is now next in importance to Saginaw. The river Au Sable is over ninety miles in length, and drains a region of more than 1,700,000 acres, a large part of which is valuable pine land, the remainder being good farming land, which will be occupied as the country is opened up.

During last season 150,000,000 feet of pine were cut on this river, one firm alone manufacturing 30,000,000 feet. This large business is done on the lake shore at piers built for the purpose, but when the weather is rough it is unsafe for vessels to remain at these piers, and they find a convenient shelter in the harbor.

The arrivals and departures from this port during the fiscal year numbered 168 steamers, and 370 sail-vessels; the latter having capacity to carry from 150,000 to 300,000 feet of lumber.

There were also put up and exported 5,000 barrels of fish, and imported about 23,000 tons of general supplies, consisting of hay, grain, provisions, and camp stores. The river at this time is almost constantly full of vessels and rafts of timber, so that at times it is difficult to work a small boat either up or down.

The prospects of the place are very flattering, based principally upon its facilities for handling the vast amount of pine timber growing in the area drained by this river, which forms the natural outlet for it. It is situated in the collection district of Huron, between the light-house at Sturgeon Point and that at Tawas, about fourteen miles from the latter.

I do not, as heretofore, make an estimate for *completing* the work, as I now see no prospect of ever being able to say that it is satisfactorily completed, but recommend that an appropriation of $20,000 be asked for, to be applied in such manner as the experience of the current year may indicate as judicious.

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Amount available July 1, 1871; appropriations of July 11, 1870, and March 3, 1871	$10,000 64
Expended during the fiscal year ending June 30, 1872	7,415 42
Balance June 30, 1872	2,585 22
Of this balance the sum of $539 20 exists as retained percentage on the forfeited contract of Wm. H. Patten.	
Appropriation of June 10, 1872	10,000 00
Total available for fiscal year 1872–'73	12,585 22
Amount of estimate for carrying on the work for the fiscal year 1873–'74	$20,000 00

C 4.

SAGINAW RIVER.

As proposed in my last annual report, the appropriation of $1,500 at that time available for the improvement of the mouth of Saginaw River, Michigan, was expended in making a survey for the purpose of determining the condition of the work, and the requirements, if any. The survey was intrusted to Colonel H. A. Ulffers, civil engineer, and his report and map are appended hereto.

The results of this survey show that no essential change has taken place in the improvement, and that it still subserves a valuable purpose. The few spots where less than 12 feet of water were found are probably due to the action of propeller-wheels, and do not indicate an actual deposit.

Inside the mouth of the river, as well as along the lake-shore to the westward, Colonel Ulffers's shore-line does not agree with that of the lake survey chart. This is principally due to the fact that on this low flat shore a slight rise or fall of the water in the lake makes a great change in the shore-line. Moreover, there is always great difficulty in fixing upon any shore-line, as the growth of wild rice and rushes is such that the shore-line may be taken anywhere within limits considerably separated.

I do not think that anything will be required to keep this improvement in good condition during the next fiscal year, and, therefore, make no estimate.

The sum available July 1, 1871, was	$1,387 25
Amount expended during the fiscal year ending June 30, 1872	1,387 25
Balance available July 1, 1872	Nil.

DETROIT, MICHIGAN, *April* 15, 1872.

GENERAL: According to instructions dated August 28, 1871, I left Detroit on the evening of the 29th and proceeded to the mouth of Saginaw River, Michigan, to make a survey showing the condition of the improvement at that point. I arrived at Bay City on the afternoon of August 31, engaged a party and provided the necessary outfit. On September 2d, the boats and implements which I had been authorized to procure from Major J. A. Smith arrived from Port Hope, and on September 4 I commenced operations.

The improvement at the mouth of Saginaw River consists of a channel 180 feet wide, dredged across the bar to a depth of 12 feet, and marked by buoys (one can, and nine spar buoys) on both edges. The erection of range-lights had been contemplated but never carried out by the Government; two small platforms with lights were procured and maintained by voluntary contributions of the owners of shipping.

The instructions calling for data which should enable me to construct a map in considerable detail, so as clearly to show the improvement and illustrate any changes that

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may have taken place in the channel since dredged, I first proceeded to establish observing stations (tripods) on shore, at considerable distances apart, the outer buoys being fully 9,000 feet from shore. After these stations were accurately determined by base lines repeatedly chained and triangulation, I set out flag-buoys, each of which was observed from not less than three stations.

The main portion of the work, the area of dredged channel, was sounded over very carefully, the distances between soundings being on an average about 40 feet.

During the progress of the work, I constructed a map on a scale of 1.2500, embodying all the results obtained daily. The soundings were all referred to the plane of low water adopted at the time of dredging, as obtained from the original bench-mark on the steps of the Saginaw-bay light-house. During my stay there the water never obtained a stage as low as this.

From an inspection of the map, it appears that although the depth of the improvement is in some parts reduced to little more than 11 feet from the original 12, yet the usefulness of the channel is but little if any impaired. The fall season of 1871 was considered to be one of lower water than usual, yet the actual depth found in the channel was but in a few instances found to be two or three inches less than 12 feet, and almost uniformly a good deal more. I do not think the improvement can be said to have deteriorated to any appreciable extent, up to the present time.

Owing to the denseness of the smoke, resulting from the burning woods all over this district, during the latter part of September and October, the soundings outside (or east) of the channel, which had been contemplated for the completion of the map, could not be carried out. It frequently was so thick, for several days in succession, that I could not see further than a few hundred feet in any direction.

Incidentally to this work, and in obedience to verbal orders, I made a linear survey of the light-house reservation, and of such tracts of land adjacent to its southern boundary as were designated in a map furnished by you, to be acquired for range-light purposes.

As a starting-point I used a stake, established by the county surveyor as a quarter-section corner, between sections 3 and 10, township 14, range 5 east, from which point, running due north, I established the southwest corner of the present light-house reservation, in accordance with the field-notes of the original survey, dated June 11, 1839. This point was marked by an oak post, 8 inches thick, and 4 feet in the ground. From this point north, the original survey calls for 11.50 chains, or 760 feet, to the shore of Saginaw Bay, which would bring it to the outer edge of one of the several ridges, extending parallel to the shore, but more than 400 feet inland from the present shore.

From the stake at the southwest corner I then ran, according to the original field-notes, south 54°, east 43 chains, at which distance I found myself in the midst of a swamp entirely impassable further on that course, but still far distant from the point called for in the description, which is the shore of the Saginaw River.

It is presumable that the surveyor, at that early day, contented himself with the bearings of the lines, and guessing at the almost inaccessible distances, as it is improbable that the shore should have gained as much as that in thirty years. In many cases it may, moreover, be a mere matter of opinion as to which is to be called land and which water, as most of the shore above the light-house is a succession of sloughs and rice swamps. It is, however, certain that the shore of the bay north of the light-house has not changed to any appreciable extent since 1856, the time of the United States lake survey at this point.

A survey of the outer parcels of land, designated on the map as part of lot No. 3, section 3; part of lot No. 4, section 3; part of the northeast quarter of the northeast quarter of section 10; and part of lot No. 1, section 11, was found to be impracticable, owing partly to the prevailing smoke, and partly to the fact that all those fractions really consist more of water than of land, being navigable to heavy boats through all their extent, and covered with wild rice.

As above remarked, the shore line of the lake has not perceptibly changed since the time the United States lake survey has operated here. The only reliable point of comparison I was able to establish is the light-house, which point, in conjunction with the true meridian, should be sufficient to enable us to compare the two surveys. Accordingly we find that the western lake-shore, the channel of improvement, and the soundings generally agree closely. Above the light-house, and on the eastern shore, scarcely a point of resemblance can be found, and I suppose that the surveyors at that time did not think it necessary on this indefinable shore to do more than establish observing points for their soundings.

The meridian obtained by me was established by corresponding altitudes of the sun by theodolite, but no correction made for change in destination, as I had no almanac with me.

Respectfully submitted.

H. A. ULFFERS,
Civil Engineer, Assistant.

Major O. M. POE,
United States Engineers, Brevet Brigadier-General, U. S. A.

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C 5.

HARBOR OF REFUGE ON LAKE HURON.

Under the act of Congress approved March 3, 1871, appropriating $100,000 for this work, examinations and surveys were made at three points, namely, Port Hope, Sand-Beach Bay, and Blue Ledge, with a view to determine which of these offered the greatest advantages for the location of the proposed harbor.

These surveys and examinations were minute in their character, and were not completed until the 31st of August, when I reported the fact, and as there was much strife between the three points, each claiming that it possessed advantages not found at either of the others, I hesitated to recommend either of them, more especially as neither of them appeared to satisfy al lthe conditions of a good site. Accordingly, under date of the 30th September, I requested that a board of engineer officers of high rank be convened for the purpose of definitely selecting the site for the harbor. The board met at the engineer office in Detroit, on the day specified, and after such an examination of the subject as was then possible, submitted the following report:

Proceedings of a board of engineers convened at Detroit, Michigan, by virtue of paragraph 2, Special Orders No. 136, dated Headquarters Corps of Engineers, Washington, D. C., October 12, 1871.

DETROIT, MICHIGAN, *October* 19, 1871.

The board assembled pursuant to the following order:

[Special Orders No. 136—Extract.]

"HEADQUARTERS CORPS OF ENGINEERS,
"*Washington, D. C., October* 12, 1871.

* * * * * * *

"2. A board of engineers, to consist of Colonel J. N. Macomb, Corps of Engineers; Lieutenant-Colonel I. C. Woodruff, Corps of Engineers; Major C. B. Comstock, Corps of Engineers; Major O. M. Poe, Corps of Engineers; and Captain F. U. Farquhar, Corps of Engineers, will assemble at Detroit, Michigan, on the 19th instant, or as soon thereafter as practicable, to examine and report upon the best site for a harbor of refuge on Lake Huron, Michigan.

"The board will visit the two localities recommended for the harbor, Port Hope and Sand-Beach Bay, and will especially examine into the nature and extent of their holding-grounds. They will ascertain the views of persons engaged in the commerce and navigation of the lakes, and will report fully upon the most suitable site for the harbor of refuge, its plan, the form, dimensions, and mode of construction of its breakwater or piers, and accompanying the same with an estimate of the cost of its construction.

"Major Poe will submit to the board his reports, maps, and plans upon this subject, and all other papers and information relating to it in his possession.

"By command of Brigadier-General A. A. Humphreys.

"THOS. LINCOLN CASEY,
"*Major of Engineers.*"

All the members being present, the president, Colonel J. N. Macomb, Corps of Engineers, United States Army, called the board to order:

After the reading of the above order, Major O. M. Poe, Corps of Engineers, United States Army, laid before the board the papers, plans, and other information in his possession, relating to the proposed harbor of refuge.

The board then proceeded to the discussion of the plans laid before them.

Adjourned at 6 p. m., to meet at 9.30 a. m.

OCTOBER 20, 1871.

All the members present.

The board continued the discussion of the plans.

Adjourned at 6 p. m., to meet at 10.30 a. m.

OCTOBER 21, 1871.

The board sailed in United States steamer Ada, to examine the localities recommended for a harbor of refuge at Sand-Beach Bay and Port Hope.

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OCTOBER 22, 1871.

The board made examinations at Sand-Beach Bay and Port Hope.

At Sand-Beach Bay the steamer was anchored with a scope of chain of 10 to 18 fathoms, at six different points scattered over the site proposed to be covered by the breakwater. The steamer, when anchored, was backed at a slow speed, and in every case the anchor was dragged rapidly from 100 to 300 feet. In nearly every case the steamer was stopped after dragging the anchor 100 or 200 feet, and again backed, when the anchor was again dragged.

In several cases the wind alone, which was stiff and directly off shore, dragged the anchor steadily without the aid of steam. The anchor weighed 820 pounds.

Mr. Irwin, a citizen, identified with the interests of Sand-Beach Bay, from whom some information was hoped, was invited on board the steamer to meet the board, but declined. He, however, pointed out a locality where he said he had seen vessels anchor in a northeast storm. At two points in this locality the steamer was anchored, and at both places the anchor was dragged.

At Port Hope six anchorages were made, also distributed over the site about the proposed breakwater, and with the same results that obtained at Sand-Beach Bay, except at a point near the end of the wharf, at which a good anchorage was found, but in shoal water.

The board deeming that their examinations were sufficient to satisfy them that neither locality afforded the necessary holding-ground, at 5.15 p. m. started on their return to Detroit.

OCTOBER 23, 1871.

The board arrived at Detroit at 1 p. m., and, after discussion, decided on submitting the following opinion:

From the results of the examinations detailed above, the board conclude that it is not advisable at present to recommend the location of the proposed harbor at either Sand-Beach Bay or Port Hope.

Although there are, in comparatively shallow water, limited areas of good or tolerable holding-ground, they are not sufficient either in extent or depth of water to justify the large expenditure which must be made to provide a harbor of sufficient area, without its being first settled that no better site exists within twenty miles to the southward, or nine miles to the westward of Point aux Barques light-house; it not being recommended in any case to locate a harbor of refuge westward of Point aux Barques.

The board are of the opinion that the site should be located as near Point aux Barques light-house as good anchorage can be found. The board, therefore, recommend that a preliminary examination be made similar to those conducted by them at all points within the limits named which offer a chance of finding good anchorage; and that when the best point is found, a detailed survey be made upon which to base a plan and estimate.

Owing to the lateness of the season, which precludes the hope of good weather of sufficient duration in which to make the examination recommended, as well as the dense smoke which now prevails, and which will certainly last until heavy and long continued rains occur, and which is quite sufficient to prevent the satisfactory use of means for determining positions, it is not deemed advisable to undertake anything further before next season, when a steamer at least as heavy as the Ada should be provided for the purpose of testing the ground by dragging the anchor.

All of which is respectfully submitted.

J. N. MACOMB,
Colonel Engineers, United States Army.
I. C. WOODRUFF,
Lieutenant Colonel of Engineers.
C. B. COMSTOCK,
Major of Engineers.
O. M. POE,
Major of Engineers.
F. U. FARQUHAR,
Captain of Engineers.

The board then adjourned to meet at the call of the president of the board.

J. N. MACOMB,
Colonel Engineers, United States Army, President of the Board.
F. U. FARQUHAR,
Captain, United States Engineers, Recorder.

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It was impossible to make the further examinations prescribed by the board before the close of the season, as it was then so late and the smoke so dense that work could not be carried on.

As soon as possible after the opening of navigation in the spring of 1872 the lake-survey steamer Ada was fitted out, and, under charge of Captain J. A. Smith, Corps of Engineers, left Detroit on the 9th of May, proceeding to Point aux Barques, where she commenced operations in accordance with the mode which was, in its general features, prescribed by the board. The steamer's anchor, weighing 820 pounds, was let go about ten times in each mile in points between the two and a half and five fathom curves, and, by backing the engine, it was ascertained whether the anchor would hold. With short lengths of cable out the lifting component of the force would be so great as to vitiate the results. To render this component as small as the time at our disposal would permit, and at the same time uniform, a length of cable was paid out equal to six times the depth of the water at the spot.

At points where the anchor resisted the efforts to drag it the cable became nearly straight, and, when the anchor caught, before it could hold it had not only the force of the engine to counteract, but also to overcome the momentum of the steamer. This resulted in frequently breaking the anchor-cable and fastenings, and often dragging the anchor where it would probably have held with a scope of cable sufficient to form a considerable curve by its weight, thus giving no lifting component, and gradually overcoming the steamer's momentum. Yet, upon the whole, these experiments were satisfactory, and the resulting data valuable.

Besides the experiments with the anchor, the bottom was examined with poles shod with steel, terminating in a long, slender point.

These examinations were continued as described until the 18th of June, when the steamer was required for lake-survey duty, at which time they had extended to a point about four miles below Barnetsville, (Rock Falls,) or a total distance of twenty-nine and one-half miles, and a little more than covering the ground indicated by the board.

Although a few points were found where the anchor held, none, save at Point Hope and Sand Beach, had sufficient extent to have any claim to the title of an anchorage, and at these they were not of such a character as it was hoped would be found.

Upon the completion of the examinations I reported the fact to the Chief of Engineers, and requested that the board be reconvened for the purpose of considering the results; and, accordingly, they met at Detroit on the 17th of July, a date subsequent to that at which this report is supposed to close. But, nevertheless, I deem it advisable to include their report, which is as follows:

Proceedings of a board of engineers convened at Detroit, Michigan, by virtue of paragraph 2, Special Orders No. 136, dated headquarters Corps of Engineers, Washington, D. C., October 12, 1871.

The board constituted by Special Orders No. 136, dated headquarters Corps of Engineers, October 12, 1871, reconvened by virtue of the following correspondence and orders, viz:

"UNITED STATES ENGINEER OFFICE,
"*Detroit, June 20, 1872.*

"SIR: I have the honor to report that the examinations prescribed by the board of engineers which convened in this city on the 19th day of October, 1871, to consider matters in connection with the location of a harbor of refuge on Lake Huron, have been completed to and a little below the prescribed point. I have, therefore, very respect-

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fully to request that the board be reconvened at such time as the Chief of Enginee may deem proper.

"Very respectfully, your obedient servant,

"O. M. POE,

"*Major of Engineers, Brevet Brigadier General United States Army.*

"Brigadier General A. A. HUMPHREYS,
"*Chief of Engineers, Washington, D. C.*"

"OFFICE CHIEF OF ENGINEERS,
"*June* 26, 1872.

"Respectfully referred to Colonel Macomb, with the request that he reconvene t board constituted by Special Orders No. 136, headquarters Corps of Engineers, Octo 12, 1871, at as early a day as practicable.

"By command of Brigadier General Humphreys:

"JNO. G. PARKE,
"*Major of Engineers.*"

"ROCK ISLAND, ILLINOIS,
"*July* 8, 187

"By authority from the Chief of Engineers, dated 26th June, 1872, the board of gineers constituted by Special Order No. 136, head quarters Corps of Engineers, Oc ber 12, 1871, is hereby directed to reconvene at Detroit, Michigan, on Wednesday, 1 July, 1872.

"J. N. MACOMB,
"*Colonel Engineers, United States Army,*
"*President of the Board.*

Met at Detroit, Michigan, at 10, a. m., on Wednesday, July 17, 1872.

Present: Colonel J. N. Macomb, Colonel I. C. Woodruff, Major C. B. Comstock, M: O. M. Poe; absent, Major F. U. Farquhar.

The results of the examinations ordered at the previous meeting of the board w then laid before them, and they proceeded to discuss them, taking a recess fro o'clock p. m. to 4 p. m. Continuing their session until 6 p. m., when they adjour to meet at 10 o'clock a. m., on Thursday, July 18.

THURSDAY, *July* 18, 187

The board met according to adjournment. Present, Colonel J. N. Macomb, Colon C. Woodruff, Major C. B. Comstock, Major O. M. Poe; absent, Major F. U. Farqu and resumed the discussion of the data before them. At 1 p. m., they arrived at following conclusion, viz:

That the results of the examinations show that the general character of the con very unfavorable for contemplated work, and that within the limits prescribed by board at its previous meeting no other points than Port Hope and Sand-Beach Bay entitled to consideration in connection with the location of the proposed harbo refuge.

That these results do not satisfy the board that they would be justified in rec mending the location of the harbor at either Port Hope or Sand-Beach Bay until determined whether or not any better locality can be found, and they therefore rec mend continuing the examination to the southward until a point is reached where rock formation disappears, provided, this distance is not found to exceed about f miles from Point aux Barques light-house.

And they recommend that the engineer charged with the work be directed to res the examinations accordingly. Also, that he be instructed to charter for this pur a steamer which in size and weight will approximate as closely as possible to the l survey steamer Ada, heretofore used but not now available, and that upon the com tion of the examinations now prescribed the board be again reconvened, with a v to the selection of a site for the harbor and the general features of the requisite structions, especially their locations and plans.

At 1 p. m. the board took a recess until 4.30 p. m., to give time for the prepar of the report, which was then submitted to them and approved.

At 5 p. m. the board adjourned to await the results of the desired examination meet again upon the order of the president of the board.

J. N. MACOMB,
Colonel of Engineers, United States Army, President of the Boar
I. C. WOODRUFF,
Colonel of Enginee
C. B. COMSTOCK,
Major of Enginee
O. M. POE,
Major of Enginee

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It will be seen that the selection of the proper site for the proposed harbor is a matter of great difficulty, and fully warrants the expenditure of time and money for preliminary examinations. To locate the harbor at some point where its usefulness would be greatly impaired would cause an unjustifiable waste of money, and it is very certain now that no satisfactory point exists north of Rock Falls. Should the site finally be selected north of that point, it would only be because nothing else could be done. It is impossible to say whether any better result will be attained by the examinations ordered by the board at their last meeting, but no course seemed to be left other than to try to find some point which would be less objectionable than those previously named. Still, it is not advisable to sacrifice position to everthing else, and it may be found that no satisfactory anchorage exists until a point is reached so near the head of the river as to exclude it on that account. The principle heretofore enunciated, that the harbor should be located as near Point aux Barges light-house as suitable anchorage can be found, should not be lost sight of.

The remarks concerning the importance of a harbor of refuge on the coast in question can only be repeated from time to time.

There can be no difference of opinion; and knowing how great will be its value to all the commerce between upper and lower lake ports, I desire to push the construction forward as rapidly as possible as soon as its location can be determined. The difficulties in this respect which beset me at the very outset, may be appreciated from the fact that a board composed of officers of great experience and local knowledge, anxious to decide the matter, find themselves still unable to do so.

The location of the proposed work is in the collection-district of Huron, and the nearest light is that of Point aux Barques. The amount of revenue collected in the district for the fiscal year aggregates the sum of $279,127.16. The number of vessels which passed Fort Gratiot light-house during the same period was 26,381, to which should be added 25 per cent. (=6,595) for vessels passing at night, and not reported by light-keepers, making a total of 32,976.

Though, as stated, Point aux Barques is the nearest light, yet the number of vessels passing Fort Gratiot light is given as being more accurate than the number reported as passing the former light, as many of them are at such a distance from Point aux Barques as to be invisible, while all concentrate at the Fort Gratiot light, and are thus brought within the observation of the keeper.

The amount available July 1, 1871, appropriation of March 3, 1871, was..	$97,013 31
Expended during the year	7,193 47
Balance June 30, 1872	89,819 84
Appropriation of June 10, 1872	100,000 00
Amount available July 1, 1872	189,819 84

Although no work of construction has yet been undertaken, and the amount available seems large, yet as the work will be put under contract as soon as the site is selected, I venture to recommend an appropriation of $100,000 for the fiscal year 1873–'74. Last year I recommended $200,000, of which one-half was appropriated, and the amount now recommended is the remaining half. But it must not be understood that this will be sufficient to make the harbor at *any* point. Wherever it may be located, it will cost at least a half a million.

Owing to the uncertainty concerning the location it is impracticable to make an estimate in detail. The foregoing is only a guess, but it will not be found too high.

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C 6.

CLINTON RIVER.

This improvement made in the latter part of the season of 1870 consisted in simply dredging a channel across the bar at the mouth of the river. At the time I expressed the opinion that, under the operation of the same causes that originally formed the bar, the channel would fill up, and the results of a survey, made only one year after the dredging was done, show how rapidly that action proceeds. I transmit herewith a chart showing the results of the survey, the soundings having been reduced to the stage of water at the date of the dredging. An inspection of this chart shows only a little more than 6 feet of water on the shoalest parts of the bar, at a point where, as throughout the channel, the depth was made 9 feet. This fact shows how useless it is to simply dredge a channel across this bar, and the commerce of the river is not sufficient to warrant a large expenditure in the construction of piers, which at best would give but little hope of any better result, as it is almost certain that the only effect would be to transfer the bar from its present position to the outer end of the piers.

I append hereto a report by Colonel H. A. Ulffers, who made the survey. He suggests a curved channel, beginning just outside the old light-house. If such a channel were made, and not protected, I would expect no better result than from the straight one, as there would always be some point where the current would be directly opposed to the current of the north channel of Saint Clair Flats, and at that point the deposit would take place all the same. Indeed, the effort of nature is to make the channel straight out, showing that in that direction the opposition is least. If the curved channel were made and protected by piers, it might possibly keep open; but, as already remarked, the cost would be out of all proportion to the importance of the place, as shown by the statistics included in Colonel Ulffers's report. His suggestion to protect the channel by plantations of wild rice is entitled to some consideration, and I recommend that when opportunity offers the experiment be made. While I do not recommend an appropriation for this work, yet if one be made, I will try the experiment of the curved channel with wild rice protection. In this case the appropriation should not be less than $8,000. The commerce is local and unimportant.

Clinton River is in the collection district of Detroit, the nearest light-house being at Saint Clair Flats.

Amount of funds available July 1, 1871, appropriation of March 3, 1871	$1,500 00
Expended during the fiscal year ending June 30, 1872	1,489 25
Balance available July 1, 1872	10 75

DETROIT, MICHIGAN, *April* 10, 1872.

GENERAL: In obedience to instructions received October 18, 1871, I proceeded with the party and outfit of the Saginaw River survey to the mouth of Clinton River, in Lake Saint Clair, to examine into the condition of the improvement at that place, and to report any alterations that might appear desirable.

The improvement consisted originally of a channel 100 feet wide, dredged to a depth of 9 feet, for a distance of about 2,700 feet, to the 9-foot curve in the lake. The cut is straight, and runs directly against the north channel of the Saint Clair River, a current from which is at times quite perceptible on the shore. The consequence is, that the channel is sanding up quite rapidly, and more so at its outer end, where the depth, after one year's interval, has already decreased to 6 feet. Outside of the one-fathom curve it is completely obliterated. It is evident, therefore, that a straight cut, even if

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protected, will not answer the purpose at this place. A reconnaissance for a curved channel, commencing near the general shore-line, was abandoned, as the off-shore soundings showed shoal water to too great a distance to be at all practicable. A new line was, therefore, selected, commencing outside of the old light-house, which, in its curved part, would be about 1,400 feet long, and require an excavation of 26,000 cubic yards for a depth of 10 feet and a width of 100 feet. This would undoubtedly be preferable to the straight cut, but still need protection, at least along its northeastern edge. Such a protection in the shape of crib-work would, however, probably be considered far too expensive, in consideration of the very limited importance of the commerce to be benefited. The trade of Clinton River is confined at present to the carrying of cord-wood to the Detroit market, two small steam-scows being the only vessels employed during the season. Larger vessels cannot navigate Clinton River, on account of the exceedingly sharp bends which characterize it from its mouth to Mount Clemens.

If, however, the restoration of the improvement should be decided upon, I would offer a plan of protection to the channel which, although untried, I am confident would prove effective in cases similar to the one in question.

All along this shore of Lake Saint Clair, as well as in many localities of the other lakes, the wild rice grows abundantly and luxuriously in water from 1 to 5 feet in depth. This wild rice often grows reef-like far out into the lake, and I had frequent occasion to observe that the lee of these reefs afforded complete shelter from the waves outside. Even a narrow reef, of say 20 feet in width, completely breaks the waves, and only admits a gentle swell to pass through; while a greater width excludes even that, and leaves the water behind it quite smooth.

If, then, all the excavated material should be banked up on either one or both sides of the cut, until it reaches the surface of the water, and this sown immediately in with wild rice, it is expected that a barrier would be formed affording full protection from wash and sediment. Of course, the plantation would at first have to be protected by brush or fascines, but after a year's growth the plants would be sufficient protection to themselves and the embankment.

I would add that the cultivation of the wild rice of these lakes has lately been undertaken in Europe with complete success, where it was found that it would germinate freely in water not less than two inches deep.

The experiment would be inexpensive, and I would recommend that it be tried, when occasion offers, in some fitting locality, and on a small scale.

Respectfully submitted.

H. A. ULFFERS,
Civil Engineer, Assistant.

Major O. M. POE,
United States Engineer, Brevet Brigadier General, U. S. A.

C 7.

SAINT CLAIR FLATS CANAL.

This work was transferred to my charge on the 11th of December, 1871, by Brevet Major General T. J. Cram, Colonel of Engineers, (retired,) under whose supervision the canal had been made. This report will include none of the operations carried on previously to the time named above.

Since I have been in charge the injury to the upper end of the western pier, caused by a barge running into it, has been repaired.

Deeply loaded propellers, and vessels of heavy draught, sometimes ground in the canal. In the first case the boat is apt to swing around with her stern near one of the piers, and if, as is usually done, the machinery is worked in this position the earth-filling of the embankment runs out through the cracks in the sheet-piling in the immediate vicinity of the rapidly revolving wheel of the steamer. In the second case the tug which has the vessel in tow causes similar damage, in exactly the same way, though not herself aground. The swash of the sea in heavy weather acts in almost precisely the same way.

All these causes combined have injured the embankment to some con-

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siderable extent, and the only ready method of repair is to so use marsh sods as to completely stop a leak wherever one is discovered. This is done by placing the sods in contact with the sheet-piling, and then filling with earth the holes in the embankment back of them. This method, thus far, has proven quite efficient, but is expensive, though the cheapest that has yet been devised.

The only complete remedy is to drive another line of sheet-piling parallel with the first, and a short distance from it in the direction of the channel, and then, with clay, puddle the entire space between the two systems of sheet-piling. This would be quite expensive, and as the other plan seems to answer present purposes I do not deem it advisable to estimate for the more costly but perhaps more thorough plan.

The depth of the canal, referred to the datum plane, is essentially the same as when the work was completed. It is possible that a deposit of an inch or two may have taken place, but whatever it may be, it is so slight as to be detected with difficulty. But a deposit is being made at a distance of about 1,000 feet below the lower end of the canal, that is to say, the material held in suspension is carried by the current until it meets the still water, where it is deposited. There is now more water in the canal than on the bar thus formed, and I see no remedy for the trouble. Temporary relief may be obtained by dredging, or the pier system may be extended to this point, with the full knowledge that a similar bar will form just outside of the extended piers; and the struggle thus carried on from time to time until the canal reaches from one end of Lake Saint Clair to the other. Of course this would be a work of some time, but it is nevertheless sure.

In view of this, I do not recommend any extension of the pier system, but instead, that resort be had to dredging whenever it is found that the accumulation on the bar is such as to neutralize to any extent the advantages of the canal.

The canal being a fact accomplished, I do not feel called upon to discuss the engineering questions connected with its design and location, but deem it my duty simply to suggest such measures as seem to me to be necessary to make it as valuable as possible to commerce. I therefore submit the following recommendations, viz:

Continue the system of stopping with sods whatever leaks appear in the sheet-piling, and refilling the holes in the embankment behind them with earth.

Dredge a channel of 16 feet in depth, and 200 feet in width, along the axis of the canal (and its prolongation at either end) from the deep water above the canal to deep water below.

To make a channel of the width and depth named will require the removal of about 200,000 cubic yards of material, which, at 40 cents per cubic yard, will cost $80,000; and to pay the custodian of the canal and furnish sods and labor stopping the leaks will cost $5,000; total, $85,000.

This estimate is based upon the supposition that no quicksand is encountered during the excavation. Should any be found the amount of the estimate will not suffice to make the channel, nor is it possible to estimate with any degree of accuracy the sum which, in that case, will be required.

The location of the work is in the collection district of Detroit, and the nearest light (except those located on the embankment at either end of the canal) is that at the head of the "cut" or artificial channel through Saint Clair Flats.

The amount of revenue collected in the district during the year end-

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ing June 30, 1872, was $283,427.28, and the number of vessels passing Saint Clair Flats in daylight during the same period, as reported by the custodian of the canal, was 5,521 steamers, 6,639 schooners, and 752 barks.

The amount of funds available December 11, 1871, the date at which I took charge of the work, was of the appropriation of July 11, 1870	$2,662 16
Appropriated by act approved March 3, 1871	1,500 00
Total available	4,162 16
Expended to July 1, 1872	2,205 16
Balance	1,957 00
Appropriated by act of June 10, 1872	4,000 00
Amount available July 1, 1872	5,957 00
Amount required for fiscal year 1873–'74	$35,000 00

C 8.

HARBOR OF REFUGE, LAKE HURON, MICHIGAN.

UNITED STATES ENGINEER OFFICE,
Detroit, Michigan, September 30, 1871.

GENERAL: By letter from the office of the Chief of Engineers, dated March 14, 1871, I was informed that, by act of Congress approved March 3, 1871, the sum of $100,000 had been appropriated for a harbor of refuge, Lake Huron, Michigan, and directed to take charge of that work, and to submit for approval, at as early a day as practicable, a project for carrying it on.

Preliminary to the final location of the harbor, I deemed it necessary to institute minute surveys and examinations, with a view to giving effect to the following opinion contained in that portion of my supplementary report entitled "Examinations for a harbor of refuge between Point aux Barques and Saint Clair River, Michigan," transmitted with my letter of October 14, 1870, to wit: "I am decided in my opinion that the harbor should be as near Point aux Barques as the other and most important condition of good holding-ground will permit."

The organization of a surveying party was proceeded with, in order that the work might be commenced as soon as the season would permit. On the 1st of April, Captain Jared A. Smith, Corps of Engineers, reported to me for duty, in accordance with paragraph 7, Special Orders No. 124, War Department, dated Adjutant General's Office, Washington, March 28, 1871, and was immediately "placed in charge of the operations in connection with a harbor of refuge on Lake Huron."

It was not until the early part of May that I deemed the weather sufficiently settled to warrant undertaking the field-work of the survey. Accordingly, under date of the 3d May, I instructed Captain Smith as follows:

DETROIT, MICHIGAN, *May* 3, 1871.

CAPTAIN: Upon the return to this city of assistants Ulffers and Cram, now engaged in the survey of the Middle Ground at Black River, you will consider them as under your orders, and, with them, will proceed by the first available opportunity to Port Hope, near Point Aux Barques, and begin the surveys and examinations required to definitely locate the proposed harbor of refuge on Lake Huron. Of the character of these surveys and examinations you are fully advised, and, therefore, nothing in the way of detailed instructions is needed.

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After the surveys and examinations at Port Hope are completed, you will transfer your party to Sand Beach Bay, and afterward to Blue Ledge, making at each place examinations and surveys similar to those at Port Hope.

You will construct your maps in the field as each survey progresses, and as soon as completed will send a copy of each to this office. * * * * It is desired that you will, by boring, ascertain with accuracy the "holding-ground" at each of the points. The borings must be sufficient in number to leave no doubt in the case.

* * * * * * *

Very respectfully,

O. M. POE,
Major of Engineers.

Captain J. A. SMITH,
Corps of Engineers, United States Army, Detroit, Michigan.

DETROIT, *Michigan.*

MAJOR: I have the honor to submit the following report of completed surveys and examinations for locating a harbor of refuge in Lake Huron. The soundings being made, and borings required at date of my former report, were completed on the 5th of August; the weather being so rough that but eleven days were actually occupied on the work after June 30.

The soundings obtained were platted on an extra sheet, and covered in detail the location proposed for cribs, as well as a large portion of the anchorage.

In the borings previously made, viz, eleven at this place and nine at Sand Beach, the action of the auger used, a common bit, was unsatisfactory, from the difficulty with which it penetrated surface layers of cobble-stones and gravel. A new auger was made, consisting of a semi-cylindrical pod, with a point resembling a gimlet; this, like the former, was worked in an iron tube adjusted for depth of water. With this apparatus no difficulty was experienced, even in boring some of the softer formations of sandstone.

Of twenty borings made at Port Hope thirteen indicate blue clay; two others indicate a good holding ground, though not finding this material; and the remaining five, which indicate a hard or rock bottom, are all outside the limits of the anchorage protected by the proposed pier. A large number of examinations were also made with poles, shod with heavy pointed spikes of iron, projecting about 15 inches beyond the end of the poles.

Through courtesy of the owners and master, the tug J. H. Martin was used in attempts to drag a small anchor of 340 pounds. From one arm of this anchor the point and palm were broken. It was first dropped outside (south) of the limits proposed for a harbor, and dragged a short distance to the area, before found to be clay, where it caught and held. It was then let go within the above place, and immediately resisted completely all efforts to drag it, notwithstanding less than twenty fathoms of cable were out, and in five fathoms of water. I was informed by the master of the tug that the amount of steam up was but about half the allowance, but that it was sufficient to take a large vessel up to her anchor in a stiff breeze. In this latter experiment the broken arm was downward, and when raised was covered with hard blue clay.

All the foregoing indicate a stratum of this clay, generally covered with a single layer of cobble-stones and sometimes gravel, the depth of the clay being found, in two instances, once 3 feet 2 inches, and in the other place 5 feet 2 inches, Nos. 12 and 15. The published lake-survey chart of Lake Huron states, in a marginal note, "Good holding-ground will be found in 6 and 7 fathoms north and east from dock at Stafford's mill;" and the chart of Saginaw Bay and part of Lake Huron, by same authority, marks clay in about five fathoms, and east of the same dock.

Were a further confirmation of the anchorage required, it might be had in the fact that vessels often "let go" in this place when unable to weather Saginaw Bay, and I have an instance recorded in my journal of a barge with seven vessels in tow holding by her single anchor, in a high wind, an entire day. When leaving, as she was compelled to do for the river, I observed that it was with difficulty she could move the tow against the wind and sea.

Of the borings at Sand Beach, twenty in number, only one, No. 10, indicates a material which would catch and hold an anchor. This boring penetrated 6 feet without reaching the underlying rock. The material obtained was a firm mud, composed almost entirely of very fine grit, worn from the sandstone formation, and though sufficiently firm to hold an anchor, it had some of the properties of a quicksand. This is in 14 feet of water, and in its vicinity on both sides weeds grow to the surface. At a distance of 650 feet from the above, very hard rock was found in 11 feet of water, with no covering save cobble-stones and bowlders, some of the latter being very large. Of the remaining borings less than one-half indicate any covering to the rock save pebbles, cobble-stones, or bowlders. A depression occurs in the sandstone formation, producing a trough or valley extending from shore in a northeast direction. The rock in

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this valley is soft, and near shore in places nearly disintegrated or rotten. On the south and east a ridge of hard rock extends, so that 14 feet of water is found over 3,000 feet from the nearest land, and over 4,000 from the bottom of the bay. This ridge catches the drift moving southward along the shore, and through its agency a large beach has formed, giving the township as well as the bay its name. The drift consists mainly of sand, sometimes mixed with mud and fine grit, forming a quicksand, and is so soft that the boring apparatus scarcely detected its presence, and it was necessary to obtain samples by other means; its depth varies with the irregular surface of the rock, diminishing with its distance from the bottom of the bay; the greatest depth, aside from that already mentioned, being 2 feet 7¼ inches. The examinations upon the ridge or reef show it to be a hard-rock formation partially covered with cobble-stones, shingle, and bowlders. The surface of the ledge is so hard as to require considerable labor with a drill to make a perceptible impression. Examinations were also made with the iron-shod poles, invariably finding sandstone.

The anchorage found is of such limited extent, and in so shallow water, as to be of little or no value for the general commerce of the lake in any wind which would cause the vessel to lie between her anchor and the shore.

At Richmondville, or Blue Ledge, of eighteen borings nine indicated clay, or a material equally good for a "holding-ground," the greatest depth being *five feet eight inches*, and the least but *seven inches*. Of these nine, four were in steps or seams of the rocks, the direction and extent of which could be distinctly traced, usually running parallel with the shore.

The remaining nine were in rock of various degrees of hardness, in places covered a few inches with sand. A large number of examinations had previously been made with the pikes, the results being far less favorable to an anchorage than the borings. The bottom is extremely regular, approximating an inclined plane, 18 feet of water being obtained about 1,500 feet from shore, the depth uniformly increasing with the distance out. The general formation is rock, though more argillaceous and, in places, softer than was found farther north. Its stratification is distinct, and steps and seams can be seen in places. The examinations indicate that in these steps and seams are deposits of what appears a disintegrated, soapy shale, resembling blue clay in color and texture. While there are places where an anchor would hold, there are a greater number where it would not. It would, perhaps, be with great difficulty that a vessel would be dragged ashore with a good anchor, but there would be no surety that she would not drag five hundred or even a thousand feet when she first lets go.

The foregoing simply indicate the character of the *bottom* at the places examined.

In order for a harbor to be a place of refuge, it must be accessible for vessels of all classes in all winds and seas. The commerce passing this part of Lake Huron is, in many respects, peculiar, and the amount passing this central part of the great lake thoroughfare can scarcely be estimated save by taking the combined tonnage of the lakes. The cargoes embrace nearly every variety of wood, grain, and mineral.

Besides vast numbers of steamers and sailing-vessels, there are freights of immense value in barges and other vessels, eight being a very common number drawn by a single steam barge or tug. The rigging and crews of most of these vessels are so small as to render them nearly helpless when adrift. A large proportion of the lake freights is now transported in this manner, which is rapidly increasing. Its unwieldy form and slow speed place it in great need of a shelter, which must afford a most ample entrance and room to be of service. A hundred and ten miles of this coast, traversed by a far greater commerce than any other equal distance on the entire lakes, has no shelter whatever for vessels in storms from the north or any easterly point, while the forty miles of this distance, adjacent to Saginaw Bay, is among the most exposed portions of the entire inland navigation.

In winds from southwest to northwest vessels have no difficulty in approaching the bay on either hand, when they would not venture to pass it, or when, having passed, they are frequently much crippled, requiring protection near at hand. In a change of wind, which often occurs, they are compelled to run a long distance for shelter, or accept the alternative of remaining without it.

So far as I can ascertain from the published charts, or my own observations and inquiries, there is no place nearer than Port Hope to Point aux Barques at all adapted to the requirements of a harbor. Were there such a place, it would become exposed to winds and seas from northwesterly directions, and be less readily reached. The sea in these winds affects the shore at Port Hope but little; I have reason to believe even less than a few miles further south. The light-house is less then seven miles distant, and can be distinctly seen when out one and three-fourths miles from shore, giving vessels from the north every possible guide to a harbor, as its ranges would be seen long before the light disappeared. The light would guide an approach from the south directly to the place, with the additional security that the shore could not be reached with its rays in view. In approaching Sand Beach the light would be distant fifteen miles, and could be seen only when six or more miles from shore, when it, as well as harbor ranges, could hardly be seen, save in clear weather. Were a harbor still farther south, it

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would require the building of an additional light-house to mark its position. To my mind every indication of position and physical relation points to Port Hope as the most suitable and desirable place for a harbor of refuge to be obtained on this shore. In this opinion I have not considered the place itself, though it offers many advantages not secured elsewhere. Its supplies of wood, which are immense, make it a wooding place for steamers, and this traffic would be largely increased were a greater security of landing afforded. Steamers often land here when unable to do so on the south shore of Saginaw Bay, making this the link by which connections are made with other places. In point of manufactures and general prosperity, there are few places on the shore which rival it.

At Sand Beach there is barely wood for local consumption; no manufactures save a few shingles, and no business interests, save those purely local. Richmondville would furnish large quantities of wood, and some lumber, but aside from these will have little importance for years to come.

As no plans have been proposed for a harbor at Port Hope, save that of Mr. Stafford, which in some respects fails to meet the requirements, I herewith submit a single plan, with my reasons for its adoption:

About 3,000 feet from the two-fathoms curve, let a breakwater be constructed 2,500 feet in length, its direction parallel with the shore, or one point west of north; its south end nearly east from the present wharf, and a wing 1,500 feet long running from the north end toward shore, making an angle of 106°. With the present surface of the lake the greatest depth of water through which the cribs would pass would be a little over 30 feet, the maximum height of cribs would be 38 feet, and its base should be equally large. On the south and west extremities of this pier, and on the east end of the present wharf, range-lights should be placed. The south of the harbor would be entirely open, giving a broad, ample entrance in four to five fathoms of water, and no obstacles to an entrance from any direction. An excellent entrance would also be obtained on the north in 20 feet of water, whence vessels could safely enter and leave when their draught was not such as to cause them to strike in that depth. The present surface of the lake is somewhat above its average height. Connecting the soundings of my surveys, approximately, and as near as opportunities permitted, with the levels recorded by the lake survey, I find the highest record shows 1.2 feet above, and the lowest 4.3 feet below the present surface of the water; the extreme records occurring but once, the former in 1838 and the latter in 1819.

Fluctuations, involving 1½, and in some cases 2 feet below the present level, are to be expected. This would diminish the area of anchorage and depth of entrance, though still leaving a depth of 18 feet in the northern, and ample room with over four fathoms in the southern entrance.

Applying these conditions to Sand-Beach Bay would divest it of whatever claims to anchorage it may now possess, while the presence of the reef on its south must render an entrance in a north or southeast storm hazardous in the extreme. The draughts of vessels now being built are only limited by the depth of communications between the lakes, or about 14 feet, a few of as great as 14½ feet draught being afloat. These vessels in a high sea are not safe in less than 20 feet of water, and most sailing-masters would rather weather a storm than risk them in that depth. It is, therefore, essential that a good depth of water be afforded until a lea be gained. But few storms prevail from southerly directions, and rarely of sufficient force to endanger navigation in this part of the lake. Vessels in this vicinity in such storms readily obtain shelter behind Point aux Barques. A harbor open on the south is therefore subject to little or no objection in discussing simply a question of safety, and should the convenience of commerce require it at any future time, the seas from that direction could be broken with comparatively little expense.

Besides the pier mentioned, I would add a smaller one on the north, leaving an opening of 500 feet, its outer end to be southwest from the end of the main wing, and its length to be 800 feet toward shore, where it would reach 8 feet of water. This is not absolutely essential for safety, but would add greatly to the anchorage and convenience, its cost being small. The area within and north of these piers would afford considerable shelter from southerly winds, and the area of protection from other directions would be equivalent to a half-mile square, outside the 12-foot curve, two-thirds of which would be deep enough for all classes of craft in all stages of the water. I submit plans for the construction of the breakwater in cribs 75 feet in length, filled with stone 4 feet above the present water-surface. The portion near the angle being much exposed, should be re-enforced with extra timbers and iron plates, to resist any action of the ice. Stone may be readily obtained in the vicinity, both from quarries and the surface of the land. The latter are about 20 per cent. heavier than the quarried stone, and should be used at least for the more exposed portions of the work. It is not likely that any accumulation of sand would obtain within the harbor, as the adjacent shores have a bottom of ledge rock; and the wharf, built solid a distance of 1,300 feet from shore, has caused no perceptible accumulation on either hand since being built, about ten years ago. The portions of the cribs below water I would recommend to be of such timbers as,

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being suitable, are cheapest. These are hemlock, elm, ash, and perhaps other varieties. Their cost is but about three-fourths that of pine, and they would be equally good, save where liable to rot. The price of all kinds of timber is constantly advancing, and it can be obtained for less now than at any probable future time.

The work will require—

11,839,448 feet board-measure of timber, at $14	$165,752 27
966,220 cubic feet framing, at 4 cents	39,464 80
25,795 cords stone, at $8	206,360 00
954,191 pounds iron bolts and plates, at 4 cents	38,167 64
Dredging for setting cribs	5,000 00
Contingencies about 10 per cent	45,000 00
Total for main work	449,744 71
And for eight hundred feet, in smaller cribs, at $35 per foot	28,000 00

Very respectfully, your obedient servant,

JARED A. SMITH,
Captain of Engineers.

A copy of each of the maps referred to by Captain Smith accompanies this report. The details of the pier-work of the proposed breakwater are completed and ready to be submitted to the board of engineers, hereinafter recommended, provided such a board is convened. No copy of them is submitted now, since it is possible a board of engineers may change them somewhat.

It will be seen that Captain Smith reports decidedly in favor of locating the harbor at Port Hope, and his examinations show that the prime requisite of such a harbor, "holding-ground," is found at Port Hope.

Though this holding-ground is not as good as it ought to be for a harbor of refuge, yet, contrary to my expectation, it appears to be better than at Sand Beach Bay.

In a former report upon this subject (see page 95 Ex. Doc. House of Representatives, Forty-first Congress, third session) I use the following language, viz:

I am decided in my opinion that the harbor should be as near Point aux Barques as the other and most important condition of good holding-ground will permit.

It appearing that good "holding-ground" is found at Port Hope, the choice of a location for the proposed harbor is narrowed down to that place, even admitting that the character of the "holding-ground" at Sand Beach Bay is equally good. Richmondville is deemed too far from Point aux Barques to answer all the conditions.

While selecting Port Hope as the site of the harbor, because it is nearest Point aux Barques, I am well aware that many persons of standing and judgment will differ with me, and as this is less a question of engineering skill than of opinion, concerning the requirements of commerce, their opinion is entitled to weight. I have taken advantage of every opportunity to talk with mariners upon this subject, and their expression, *to me*, has been almost, if not quite, unanimously in favor of the location of the harbor at Port Hope. But I have had little opportunity to consult masters of sailing-vessels, my inquiries being altogether limited to masters of steamers.

It seems to me that the ground upon which I founded the opinion already referred to is the correct one, namely, that the point best suited to the wants of commerce as the location of the harbor is that midway in the long stretch of one hundred and fifty miles from the foot of Lake Huron to Thunder Bay Island. Point aux Barques occupies almost exactly this relation. But there is no suitable "holding-ground" at Point aux Barques, therefore the first place to the southward where "holding-ground" is found, namely, Port Hope, is the one recommended as the site of the harbor.

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While I make this recommendation I do not mean to deny the possibility of error upon my part, and for this reason I respectfully recommend that a board of engineers, of high rank, be ordered to meet here for the purpose of considering this subject, as well as the details of the breakwater piers, which must be the same, whatever site be finally chosen for the harbor.

As bearing upon the facts detailed in Captain Smith's report, I submit herewith copy, marked A, of correspondence relating to the nature of the bottom at Sand Beach Bay. The statement, in my letter of the 14th of July, that the pile referred to had penetrated to a depth of nearly 5 feet, was based upon the assumption that the pencil-mark upon the pile, purporting to indicate the point to which the pile penetrated the ground, was accurately placed. Captain Smith's report shows that it was not.

All of which is respectfully submitted.

O. M. POE,
Major of Engineers and Brevet Brigadier-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

C 9.

SAINT CLAIR FLATS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 9, 1872.

SIR: In reply to the communication of the chairman of the Senate Committee on Commerce of the 16th ultimo, referred to this office, asking for information, suggestion, or recommendation in relation to proposed Senate bill No. 345, "For deepening Saint Clair Flats Canal to 16 feet," I have the honor to state that on a former occasion, in a letter of February 19, 1867, I expressed the belief that as the economy and security of lake navigation would be materially enhanced by increasing the size and draught of vessels engaged therein, increased depth would be demanded from time to time by the growing wants of commerce; that for the present an increased depth should be secured where the greatest amount of shipping enters, either for cargo or safety, and that the channels of the rivers connecting the lakes should be of corresponding depth.

The Saint Clair Flats Canal was planned for a 13-feet navigation at the lowest stage, and it would appear from this proposed legislation that the lake trade is already looking to an increase of its depth.

It is believed that 16 feet would be a limit which there would be no necessity to exceed. The canal is now 300 feet wide. The sum named in the bill is deemed sufficient to increase the depth to 16 feet in a cut 200 feet wide, which would be sufficient for the easy passage of vessels, and beyond which it would not be safe to extend the width for fear of endangering the canal-banks.

The communication of the chairman of the Committee on Commerce is herewith respectfully returned.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

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SAINT CLAIR FLATS CANAL.

DETROIT, MICHIGAN, *October* 3, 1872.

SIR: At the risk of appearing over-zealous, I take the liberty of urging that the full amount of my estimate for the improvement of Saint Clair Flats Canal be appropriated at the coming session of Congress. Since making my annual report, the water in the canal has been practically reduced to 11 feet 6 inches, principally due to the action of the wheels of heavily-laden propellers, and notably the propeller Philadelphia, which grounded in the canal a few days ago, and in endeavoring to force her way through worked her machinery violently, piling up the sand behind her, with the effect referred to above. Such occurrences will henceforth be even more frequent, and I anticipate the destruction of the great usefulness of the improvement unless measures are promptly taken to secure a channel of sufficient depth to enable vessels of the heaviest draught to freely pass through, and thus avoid the injurious effects sure to result whenever one of them grounds.

The Philadelphia also caused a leakage from the east dike into the channel of fully 1,200 cubic yards of the dike-filling, and that material is all in the bottom of the canal, to its great injury. Heretofore I have pursued the plan of my predecessor, and wherever such leaks occurred endeavored to stop them by the use of marsh-sods, piling them in the dike behind the sheet-piles. I have about come to the conclusion that this is wrong, and that no effort should be made to keep the cribs filled with earth. It can only be done at great expense, and the effect of loading the sides of the channel with the great weight of the dike-filling is undoubtedly to assist any tendency of the sides to *run* into the channel. This is especially the case where any quicksand occurs. This earth-filling is of no use in confining the current, since that is done by the sheet-piling and the timber-work of the superstructure. I am now very decidedly of opinion that it would have been better never to have filled the cribs. They contain thousands of yards of material dredged from the canal, a considerable portion of which will eventually find its way back into the channel, and can only be gotten out of the way by dredging. The dike-filling adds greatly to the appearance of the work; indeed the dikes, with the growth of willows upon them, look beautifully, but I have indicated at what sacrifice.

I am, sir, very respectfully, your obedient servant,

O. M. POE,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army.

APPENDIX D.

ANNUAL REPORT OF MAJOR GEORGE L. GILLESPIE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, September, 1872.

SIR: I have the honor to submit herewith my annual report upon the

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improvement of the harbors and rivers of Lake Erie, west of Dunk
New York, for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

G. L. GILLESPIE,
Major of Engineer

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

D 1.

MONROE HARBOR, MICHIGAN.

No work of improvement or repair has taken place during the y
The outer piers have not been in perfect repair, still it was not dee
necessary to do anything to them.

By act of Congress approved June 10, 1872, an appropriation
$10,000 was made for the improvement of this harbor. It will be
pended in deepening the channel from the outer bar to the city of M
roe, in repairing revetment of the United States Ship-Canal, and
closing, by piling, the old channel-bed near the head of the Un
States Ship-Canal.

Sealed proposals will be publicly invited in July for the deliver
the necessary materials and for the labor of construction.

Balance June 30, 1871	$1
Appropriation June 10, 1872	10,0
Total	10,1
Expended during the year	1
Balance June 30, 1872	10,0

The amount required to make repairs to piers, $1,000. This ha
and port are in the collection district of Detroit, Michigan.

Number of entries and departures of vessels, 166; average ton
each, 30 to 35 tons.

Amount of duties collected during the year, $68.63.

The entrance to this harbor is marked by a fixed white light of
fourth order, shown from a frame structure erected on the north pi

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D 2.

MAUMEE BAY, TOLEDO, OHIO.

The work of widening and deepening the southwest channel thr
Maumee Bay, in progress at the date of last report, under contract
Andrew Spaulding, of Buffalo, dated March 3, 1871, was satisfact
prosecuted during the year. Andrew Spaulding completed his con
June 30, after removing 200,588 cubic yards of material between
can-buoy No. 2 and black can-buoy No. 1, making a channel 120
wide with 14 feet low stage.

Charles Fitzsimons, of Chicago, commenced work in July under
tract dated June 6, 1871. He was assigned to the north branch of
channel, which extends outward from red can-buoy No. 2 in the d
tion of Turtle Island. In November he was withdrawn, and place

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the inside along the range of the outer range-lights. Amount removed to the close of the working season was 84,302 cubic yards, bank-measurement. Work was resumed in May, and it is expected that the contract will be closed in July.

The entire amount of material removed under this contract, at the close of the fiscal year, is 132,203 cubic yards, bank-measurement.

By act of Congress approved June 10, 1872, an appropriation of $15,000 was made for the further improvement of the southwest channel. It will be expended in still further widening and extending the north branch of the channel.

Sealed proposals will soon be publicly invited for dredging. During the year it has been quite difficult to keep in place the buoys authorized for marking the channel, and, but for the unremitting and laborious vigilance of the inspectors, the commerce of the port would have been much embarrassed. Mariners in charge of rafts do not ordinarily follow the improved channel, but cross it anywhere between the can-buoys, and not unfrequently displace the can-buoys, or pick up in passing all, or nearly all, the spar-buoys, break them or their moorings or throw them entirely out of position.

When such accidents have occurred in the day-time, disasters to shipping have been prevented by prompt action on the part of the inspectors, but when ocurring at night the damage done could not be repaired without some delay. It is proposed to mark the positions now occupied by the can-buoys by strong day-beacons made of timber.

Balance June 30, 1871		$104,053 64
Appropriation June 10, 1872		15,000 00
Total		119,053 64
Expended during the year	$80,982 27	
Due June 30, 1872	3,294 06	
		84,276 33
Balance June 30, 1872		34,777 31

Still required, to deepen and widen outer and inner branches of southwest channel, $30,000.

Toledo Harbor, Maumee Bay, is in the collection-district of Miami.

The first light passed, on entering harbor, is a fixed white of the fourth order, shown from a brick structure erected on Turtle Island.

Amount of revenue collected here, during the fiscal year ending June 30, 1872, was, coin, $11,899.62; currency, $8,073.91.

Number of entries of vessels, during the same period, 2,130, and of departures, 2,168, with an aggregate tonnage of 1,107,256.

D 3.

MAUMEE RIVER, OHIO.

By act of Congress approved June 10, 1872, $7,000 were appropriated for the improvement of Maumee River, Ohio. The money will be expended in cutting a 60-foot channel with 8 feet water at ordinary stage, between Maumee City and Perrysburgh, Ohio, and in deepening the channel across Delaware Flats.

Sealed proposals for dredging will be publicly invited at an early day.

Appropriation June 10, 1872, available, $10,000.

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D 4.

SANDUSKY RIVER, OHIO.

By act of Congress approved June 10, 1872, an appropriation $10,000 was made for the improvement of this river. It is proposed expend the money in making a channel, 60 feet wide, with 9 feet at o nary stage, from Fremont, Ohio, to the mouth of the river.

The improvement will commence at Whiteacre Bar, be continue the mouth of the river, and if anything remains thereafter of the ap priation, it will be expended near the city of Fremont.

Sealed proposals for dredging will be publicly invited at an early

Balance June 30, 1871	$3
Appropriation June 10, 1872	10,0
Total	10,3
Expended during the year	
Balance June 30, 1872	10,2

Revenues collected for Fremont, Ohio, during the year, $79. En of vessels, 81. Clearances, 79. Aggregate tonnage, 23,661.

D 5.

SANDUSKY CITY HARBOR, OHIO

The work in progress at date of last report, under contract O. J. Jennings, of Syracuse, New York, dated March 4, 1871, was completed till December.

The manner in which Mr. Jennings fulfilled his contract was not s factory. His machinery was bad, but the judgment of his forema organizing his force and prosecuting his work, was worse. In co quence of these embarrassments the work was much delayed.

Thirty thousand seven hundred and eighty-four cubic yards of and clay, bank measurement, were removed from the inner cha during the season.

By act of Congress approved June 10, 1872, an appropriatio $13,000 was made for the further improvement of the harbor. manner of application of this money is not yet decided upon.

After passing the Cedar Point light, there are two channels that to the wharves at Sandusky, one skirting along the west side of C Point, and called the East Channel, and the other passing to the ward of Johnson's Island, and called the West Channel. This la channel, being under the more immediate influence of the current of river and the scouring effect of the prevailing winds, has the be water, and is the one used by vessels of the largest class.

Between these channels there is a wide shoal, having at places more than 4 to 5 feet of water at low stage. At the point near the ce of this shoal it is evident that there is a tendency to the cutting, f the outside, of a new channel. When the question came up last yea applying the appropriation of July 10, 1870, the engineer then in ch submitted to the citizens whether they preferred the West Channe be improved, or to have a new channel cut through the shoal. A

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a general discussion of the subject, they asked that the West Channel might be improved, and the money was so applied.

The citizens are much divided in opinion as to the relative merits of the west channel and a new one to be cut through the shoal, and their discussion has been revived again this year. But whatever plan may be pursued, their demands are for 14 feet of water, low stage; but as the general depth of water in the bay is only about 12 feet, the water they ask can only be obtained by dredging a trench that will be 2 feet below this level.

After a careful study of the bay it is believed that the west channel should be improved. The channel has not filled at all since last year's dredging, and it is believed if the work be continued toward the inside till the 12-foot curve is reached, that the best channel will be made which the bay can furnish. This channel will receive the greater part of the scouring influence of the river, and being protected by the adjacent islands will not be so liable to fill up as a channel at any other point.

As regards a channel through the shoal, while admitting that the amount to be removed may be not greater than would be required to improve the west channel, and when opened the distance to the wharves may be lessened three-quarters of a mile; it is certain that it will have but little of the river influence, and will have to rely upon southwest or northeast winds for its maintenance.

The cutting of this channel would be but an experiment that might involve the loss of all the money expended upon it. Nature seems to have taken the west channel as the outlet for the river discharge, and it is *there*, I believe, the improvement should take place.

The survey of the bay made this spring, by the officer in charge of the lake survey, has not yet reached me, and I cannot state what point on the inside should be selected as the terminus of the improvement. A supplementary report will be made after the chart has been studied, which will give the amount still required to complete the improvement.

Sandusky City is a port in the collection-district of Sandusky, Ohio, and the harbor is marked by two prominent lights, one at Cedar Point, on the east side, a fifth-order fixed white, shown from a masonry tower and dwelling attached, and the other at Marble Head, on the west side, a fourth-order fixed white, shown from a detached stone-tower. A small light in a frame building erected opposite Cedar Point forms a range with Cedar-Point light for crossing outer bar.

Revenue collected during the fiscal year ending June 30, 1872, $23,610; entries and departures, 2,063; aggregate tonnage, 413,970.

The business of this port is increasing, and from the information given me by the leading citizens at my last visit it is believed that next year's report will show a great increase in the revenues.

As a shipping point for coal it promises to have few rivals on the lake.

Amount available June 30, 1871	$9,433 67
Appropriation June 10, 1872	13,000 00
	22,433 67
Expended during the year	9,354 94
Balance June 30, 1872	13,078 73

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D 6.

HURON HARBOR, OHIO.

No work of improvement or repair has taken place during the yea
Huron is a port in the collection-district of Sandusky, Ohio. T
harbor is marked by a fixed white light of the fourth order, shown fr
a cast-iron tower, painted white, established upon the west pier.
Revenue collected during the fiscal year ending June 30, 1872, $2
Entries, 32; departures, 32; aggregate tonnage, 7,732 tons.
No appropriation is recommended.

Balance June 30, 1871	$9,40
Expended during the year	42
Balance June 30, 1872	8,9

The piers are generally in good repair. A trifling expenditure
be made upon them during the working-season.

D 7.

VERMILLION HARBOR, OHIO.

No money has been available for any improvement during the y
There is an evidence of some enterprise in the village of Vermill
and its commerce is gradually increasing every year. It is favor
located with reference to some of the best stone-quarries in North
Ohio, and is exciting some interest as a shipping-point for stone.
By act of Congress approved June 10, 1872, $5,000 were appropria
for the improvement of the harbor. It will be expended in deepe
the channel across outer bar, and on inside near west pier, by blas
and dredging, and in making necessary repairs to piers.
Sealed proposals for labor will be publicly invited at an early day
It is confidently believed that the commerce of the harbor wil
greatly increased by the extension of the piers, in the aggregate,
feet.
Vermillion is a port in the collection-district of Sandusky, Ohio.
harbor is marked by a fixed white light of the fourth order, shown f
a frame beacon erected on the west pier.
Duties collected during the year, $90.
The following is a statement of the principal business during the y
Arrivals, 246; stone shipped, 28,550 tons; staves shipped, 414,
lumber received, 3,755,340 feet, board measure; laths received, 1,375,
shingles received, 5,543,000.

Balance June 30, 1871	$1
Appropriation June 10, 1872	5,0
Balance June 30, 1872	5,01

Appropriation recommended, for extension of piers, $25,000.

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D 8.

BLACK RIVER HARBOR, OHIO.

No work of improvement or repair has been made during the year.

By act of Congress approved June 10, 1872, an appropriation of $20,000 was made for the improvement of the harbor. It will be expended in extending the piers, in the aggregate, 330 feet; in dredging the inclosed channel; in removing the deposit of sand, gravel, and bowlders on the inside, close to the east pier, and in repairing piers.

Sealed proposals will be publicly invited at an early day for materials and labor. Black River is in the collection-district of Cuyahoga, Ohio, and the entrance to the harbor is marked by a fixed white light of the fourth order, shown from a brick tower erected on the west pier.

The collector reports no duties collected during the year. Arrivals, 85; tonnage, 5,520. Departures, 102; tonnage, 6,080.

Balance June 30, 1871	$7,910 27
Appropriation June 10, 1872	20,000 00
Total	27,910 27
Expended during the year	635 15
Balance June 30, 1872	27,275 12

D 9.

CLEVELAND HARBOR, OHIO.

The work of deepening channel between piers of entrance in progress at date of last report, under contract with Andrew Spalding, of Buffalo, New York, dated March 7, 1871, was satisfactorily completed and the contract closed in October. Sixty-five thousand six hundred and sixty-four cubic yards of sand and gravel, bank measurement, were removed from the channel.

The east and west piers were put in perfect repair by days' labor early in October; both piers received snubbing-posts at intervals of 60 feet, also new decking and partial stone-filling. In the repairs the following amounts of materials were consumed: 12,980 feet, board measure, timber and plank; 17 snubbing-posts; 72 cords of stone, and 1,062 pounds of iron for spikes and screw-bolts.

During the storms of the 14th of November both piers were considerably damaged by vessels running against them. The injury to the east pier was severe. The connection of the superstructure at the pier-head with the pile foundation was almost completely broken for a distance of 100 feet in-shore; the side timbers were crushed in and the decking ripped off.

The piers received immediate attention, and the damages were repaired before the close of navigation.

Cleveland is in the collection-district of Cuyahoga, Ohio, and the entrance to the harbor is marked by a F. V. R. F. light of the sixth order, shown from a frame beacon erected on the east pier.

The revenue collected during the year, slightly in excess of last year, was $177,531.49.

Arrivals and departures, 7,630; tonnage, 1,761,644.

Amount probably required annually for repairs to piers, $1,000.

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Balance June 30, 1871	$19,68
Allotted during year for repairs	1,00
	20,68
Expended during the year	$20,31
Part of allotment returned to Treasury June 30, 1872	36
	20,68

D 10.

GRAND RIVER HARBOR, OHIO.

In obedience to the following order from the Chief of Engineer board of engineer officers was convened at Buffalo, New York, Febru 26, 1872, to consider the subject of the improvement of this harbor,

[Special Orders No. 25.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 17, 187

1. A board of engineers, to consist of Lieutenant-Colonel I. C. Woodruff, Corp Engineers; Major Walter McFarland, Corps of Engineers; Major J. M. Wilson, C of Engineers; Captain F. U. Farquhar, Corps of Engineers; Captain G. L. Gille Corps of Engineers, will assemble at Buffalo, New York, on the 26th instant, or as thereafter as practicable, to report a plan for the further improvement of the ha of Grand River, Ohio.

The junior member of the board will act as recorder.

* * * * * * *

By command of Brigadier-General Humphreys.

THOS. LINCOLN CASEY,
Major of Engineer

After a full investigation, it was recommended to remove the su structure of the flare of the west pier and to extend both piers in aggregate 900 feet, the extension to be on the prolongation of the p on the inside.

By approval of the Chief of Engineers, dated March 9, 1872, se proposals were publicly invited to May 4, 1872, (see abstract herein materials and labor,) and a contract was made May 16, 1872, with Mes Hemenway & Garfield, of Painesville, Ohio.

A part of the material has already been delivered, and the wor framing and sinking the cribs will commence at once. The work be prosecuted with every dispatch during the season.

Both piers were put in perfect repair by days' labor in Septem snubbing-posts were added, and side timbers, decking, and stone renewed.

The following are the amounts of material consumed in the repa 49,700 feet, board-measure, timber and plank; 2,223 pounds of iron screw-bolts and spikes; and 90½ cords of stone. Probable annual of repairs during the succeeding year, $500.

Grand River is in the collection-district of Cuyahoga, Ohio, and entrance to the harbor is marked by a fixed white light of the s order, shown from a frame beacon erected upon the east pier. A coast-light of the third order, fixed white, is shown from a stone to on a hill one-fourth of a mile east of mouth of river.

Revenues collected during the year, $1,005.

Arrivals and departures, 173; aggregate tonnage, 13,402.

Balance June 30, 1871	$61,1
Expended during the year	3,9
Balance June 30, 1872	57,1

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Abstract of bids received and opened, May 4, 1872, for improving Grand River Harbor, Ohio.

Names of bidders.	Residence.	Names of guarantors.	Residence.	Class I. Timber and plank. Timber.	Class I. Timber and plank. Plank.	Class I. Timber and plank. Piles, (in place.)	Class II. Iron. Screw-bolts and washers, complete.	Class II. Iron. Drift-bolts.	Class II. Iron. Iron plates for angles.	Class II. Iron. Spikes.	Class III. Stone. Rubble-stone, in place, and measurement in place.	Class IV. Dredg'g Dredging sand, gravel, and other material.	Class V. Labor. Framing below water, inclusive of every work for completion of extension.	Class V. Labor. Framing above water, inclusive of every work for completion of extension.	Class V. Labor. Confining of joists and decking.	Amount.
				M. feet, board measure	*M. feet board meas'e.*	*Lin'r feet.*	*Per lb.*	*Per lb.*	*Per lb.*	*Per lb.*	*Per cord.*	*Cub.y'ds bank meas'mt*	*Linear feet.*	*Linear feet.*	*M. feet board meas'e.*	
				888,048	39,731	108	9,136½	58,404	460	3,255	1,105	1,600	53,497	18,720	37,730	
1. O. J. Jennings	Syracuse, N. Y.	George M. Case	Fulton, N. Y.	$25 00	$25 00	$1 00	$0 07	$0 05	$0 10	$0 06	$7 50	$0 70	$0 14	$0 14	$12 00	$47,074 16
		James Caldwell	Fulton, N. Y.													
2. E. H. French	Fulton, N. Y.	Willard Johnson	Fulton, N. Y.	29 00	22 25	31	08½	06	06	.....	10 00	85	12	12½	6 00	52,375 34
		John H. Woodin	Fulton, N. Y.													
3. S. G. Hart	.....do	Charles P. Morse	Fulton, N. Y.	28 80	28 80	1 00	10	06½	10	10	10 20	70	10	10	5 50	51,729 65
		Samuel Hart	Fulton, N. Y.													
4. D. E. Bailey	Buffalo, N. Y.	Samuel Gibson	Buffalo, N. Y.	20 00	20 00	50	07½	05	15	06½	10 00	1 00	12	12	8 00	44,082 50
		Ezekiel T. Johnson	Buffalo, N. Y.													
5. Farris & Boalt	Painesville, Ohio.	W. W. Dingley	Painesville, Ohio	22 90	20 00	75	08	05½	13	07	10 85	50	12	11	8 00	47,158 64
		C. O. Child	Painesville, Ohio													
6. Hemenway & Garfield.*	.....do	Daniel Warner, jr.	Painesville, Ohio.	21 95	21 95	50	08	05½	10	06½	8 95	50	10	09½	6 00	42,525 82
		J. E. Amidon	Painesville, Ohio													
7. Jas. Caldwell	Fulton, N. Y.	J. V. Boomer	Fulton, N. Y.	29 00	22 00	30	08	06	06	.....	10 00	80	12	12	6 00	52,145 05
		J. H. Woodin	Fulton, N. Y.													
8. A. G. Smith	Cleveland, Ohio.	Sam'l M. Carpenter	Cleveland, Ohio.	29 00	24 00	50	09	07	20	.....	9 00	40	13	11	12 00	51,815 07
		George W. Calkins	Cleveland, Ohio.													
9. C. J. De Graw	Fulton, N. Y.	Willard Johnson	Fulton, N. Y.	25 00	25 00	80	09	06	09	10	9 00	1 00	10	09	9 00	46,893 37
		R. Bradshaw	Fulton, N. Y.													
10. Patrick Smith	Cleveland, Ohio.	Patrick Smith	Cleveland, Ohio.	25 00	22 00	40	12	08	10	10	9 00	75	10	08	8 00	47,652 82
		Charles L. Fish	Cleveland, Ohio.													
11. George Nilson	Belleville, Ont.	Franklin Lee	Buffalo, N. Y.	38 00	30 00	1 00	13	09	16	09	12 00	1 00	13	10	10 00	65,920 31
		David Bell	Buffalo, N. Y.													

* Contract awarded.

BUFFALO, NEW YORK, *May*, 1872.

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Abstract of contract for each class of materials or labor for each work, with names of co tractors.

Name of work.	Name of contractor, and what he contracts for.
Grand River Harbor, Ohio.	Charles M. Hemenway & Alexander H. Garfield, of Pain ville, Ohio; for all material and labor.

D 11.

ASHTABULA HARBOR, OHIO.

The work of blasting and dredging under contract with Lee and Du bar, of Erie, Pennsylvania, dated June 17, 1871, was commenced the l ter part of July and was satisfactorily prosecuted during the seas The contract was not closed when the work for the season stopp because the contractors had failed to remove from the bed of the strea all the stone which they had blasted.

As the amount still to be removed was very small, permission w granted them to defer resumption of their work until after the letting the succeeding contract. The channel across the ledge on the insi has been widened to an average width of 30 feet, and deepened to feet, low stage, by the removal of 4,505 cubic yards of solid rock, a 3,436 cubic yards loose rock and sand.

By act of Congress approved June 10, 1872, an appropriation $15,000 was made for the further improvement of the harbor. It w be expended in cutting through the ledge to gain a depth of 14 fe low stage, for the full width between the piers and in making necessa repairs to piers.

Sealed proposals will be publicly invited at an early day for labor blasting and dredging.

No additional appropriation is recommended. Amount probably quired to keep piers in repair, $800.

Ashtabula is in the collection-district of Cuyahoga, Ohio, and the trance to the harbor is marked by a F. V. F. light of the fifth ord shown from a frame beacon erected on the east pier. Duties collec during the year, $2. Arrivals and departures, 50; aggregate tonna 3,993.

The railroad in progress of construction connecting the harbor w the coal-fields in the interior, it is believed will greatly increase t commerce of this port during the coming year.

Balance June 30, 1871		$15,566
Appropriation June 10, 1872		15,000
Total		30,566
Expended during the year	$11,528 22	
Due June 30, 1872	1,103 32	
		12,631
Balance Ju e 30, 1872		17,934

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D 12.

CONNEAUT HARBOR, OHIO.

The work of extending the east pier 90 feet mentioned in last report under contract made with Hugh N. Smith, of Buffalo, New York, dated June 17, 1871, was completed, inspected, and accepted in October. The materials expended were as follows: 90,606 feet, board-measure, pine lumber, assorted; 1,305 pounds screw-bolts; 7,539 pounds drift-bolts; 200 pounds wrought spikes, and 203 cords of stone.

The piers are in fair condition. No additional appropriation is required. Amount probably required annually to keep piers in repair, $400.

Duties collected during the year, $54.20.

The collector makes no report of arrivals or departures.

Conneaut is in the collection-district of Cuyahoga, Ohio, and the entrance to the harbor is marked by a fixed white light of the sixth order, shown from a frame beacon erected behind the east pier.

Balance June 30, 1871	$6,282 72
Expended during the year	6,282 72

D 13.

ERIE HARBOR, PENNSYLVANIA.

Under contract executed by Colonel T. J. Cram, United States Engineers, dated March 29, 1867, Contractors Lee and Dunbar, of Erie, Pennsylvania, have removed from the outer bar, during the season, 8,777⅛ cubic yards of sand.

The contract was closed in September. The work of extending the north pier 120 feet eastwardly, mentioned in last report, under contract with Hugh N. Smith, of Buffalo, New York, dated June 17, 1871, was satisfactorily completed in November, after successfully removing the wrecked cribs from the site of the extension.

The following materials were consumed: 116,681 feet, board-measure, assorted pine; 3,536 feet, board-measure, decking and joists; 22 white-oak piles; 9,215 pounds drift-bolts; 2,068 pounds screw-bolts; 280 cords of stone; and 400 cubic yards sand removed for accommodation of cribs.

The north and south piers were put in thorough repair by days' labor, under authority dated July 8, 1871.

The following materials were expended: 115,967 feet, board-measure, assorted lumber; 176 hemlock ties; 232½ cords of stone; 800 pounds wrought-iron spikes; 1,428 pounds cut spikes; 7,054 pounds screw-bolts; 662 pounds drift-bolts; and 24½ pounds paint for snubbing-posts.

It was not thought when this work was commenced that so much time, labor, and material would be required to be consumed, but the north pier is very old, and when it was uncovered there seemed to be no limitation to the work of renewal short of the removal of all of the decayed timbers in the cribs below the water-line, and of the closing of all of the openings revealed. The riprap, which was placed in front of light-house, on the east side, to prevent a threatened breach through the spit, has been most successful in its results. Not only has the abrasion been checked, but the beach has made out to the line of the new work, and the water seems to be shoaling in advance.

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The work of dredging inner channel, in progress at date of last report, under contract with Lee and Dunbar, dated June 17, 1871, was satisfactorily prosecuted, and 50,000 cubic yards of sand have been removed.

This contract will be closed early in August. During the season there have been planted for the protection of the neck of the peninsula on the west side of the bay 3,300 silver-poplars, and 4,000 American-poplars, 3 to 4 feet in height; 10,000 American-poplar roots, 4,000 willow-roots, and 30,000 willow-slips. They were all insured to July 1, 1872. An inspection has shown that about 10 per cent. have died; these will be renewed in the fall by the nurserymen.

The beach at two exposed points has been further protected by anchoring and picketing brush, laid in rows and weighted with heavy stone; consuming in the improvement 350 loads brush and 187 cords of stone.

By act of Congress, approved June 10, 1872, an appropriation of $15,000 was made for the further improvement of the harbor. It will be expended in widening and deepening inner and outer channels and in making necessary repairs to piers.

Sealed proposals for labor will be publicly invited at an early day.

Balance June 30, 1871		$42,851 35
Allotted for peninsula		6,080 00
Appropriation June 10, 1872		15,000 00
Total		63,331 35
Expended during the year	$43,359 12	
Due June 30, 1872	1,115 50	
		44,474 62
Balance June 30, 1872		19,456 73

No further appropriation is required. Amount probably required annually to keep piers in repair, $1,000.

Erie is situated in the collection-district of Erie. A harbor-light of the third order, fixed white, is shown from a stone tower one-half mile east of the city; the entrance to harbor is marked by a fixed white light of the third order, shown from a cast-iron tower erected near east end of north pier.

Revenue collected was: In coin, $29,943.97; in currency, $2,862.87; total, $32,086.84. Total number of vessels entered and cleared, 2,768; tons, 321,606.

D 14.

PORT CLINTON HARBOR, OHIO.

By act of Congress approved June 10, 1872, $8,000 were appropriated for the improvement of this harbor. The money will be expended in deepening, by dredging, the entrance to Portage River, and in running a timber revetment around east end of peninsula, on the north side of entrance to river, for a length of 1,000 feet, to protect it against further abrasion by the waves from the lake-side.

Sealed proposals for labor and materials will be publicly invited at an early day.

This harbor has no light-house. Appropriation June 10, 1872, available, $8,000.

Revenue collected during the year, $105. Entries of vessels, 168; clearances, 201; aggregate tonnage, 23,799.

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D 15.

ROCKY RIVER HARBOR, OHIO.

By act of Congress, approved June 10, 1872, an appropriation of $10,000 was made for the improvement of the harbor.

Rocky River, at its mouth, is confined between a high bluff on the west and a low sand and gravelly beach on the east. The beach is about 1,000 feet in length, measured along the shore, and is limited on the east by a bluff similar to that on the west bank of river. By a northwest wind the sand is driven from the beach near the mouth of the river, and deposited in the direction of the bluff on the east, and the entrance to the harbor is made easy for vessels of light draught. By a northeast wind of long continuance the sand is driven back, and the beach prolongs itself gradually toward the west until a connection is made with the bluff on the west bank, entirely closing the entrance, even to row-boats.

It is proposed to expend the appropriation in endeavoring to arrest the frequent disturbances of the beach by running a pier into the lake from a point on the west end of beach, about 150 feet from the bluff on west bank, and by connecting the south end of the pier with the water inside by a double row of close piling, projecting not over 3 feet above the beach. Appropriation June 10, 1872, available June 30, 1872, $10,000.

Rocky River is in the collection-district of Cuyahoga, Ohio.

No revenue collected during the year. No arrivals or departures reported. The harbor has no light. No further appropriation recommended.

D 16.

SURVEY OF MAUMEE RIVER, OHIO.

U. S. ENGINEER OFFICE, IMPROVEMENT OF HARBORS,
LAKE ERIE, WEST OF DUNKIRK, N. Y.,
Buffalo, New York, October 6, 1871.

The survey was commenced in May, and completed in June, 1871. The part of the river embraced in the survey extends from the wooden bridge at Maumee, Ohio, to the railroad bridge at Toledo, Ohio, a distance of nine miles by the channel. The survey was not extended beyond Maumee, as the rapids are met with a short distance above the bridge, which bar the further navigation of the river. The towns to be especially benefited by the improvement of the river are Maumee and Perrysburgh, situated on opposite banks, one mile apart from wharf to wharf—the former nine, and the latter eight miles from Toledo, Ohio. They are both small towns, and contain each less than two thousand inhabitants, but from their location and the number of their manufactories in active operation, with water and railroad facilities, promise to be places of some considerable manufacturing importance.

Maumee has three flour-mills, two paper-mills, one plow-factory, one cultivator-factory, one oil-mill and tannery, and one wool-factory. Perrysburgh has one flour-mill, two planing-mills, one saw-mill, two stave and barrel factories, one box-factory, one bowl-factory, one paper-mill, one tannery, and two wagon-factories. As neither place is a port of entry, and as Toledo, the nearest port, receives credit for all shipments, no accurate statement of imports and exports could be acquired; but the

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imperfect estimates received from reliable parties show that these tow
are thriving and enterprising, and that their increasing business wou
be greatly benefited by an improvement of the river, which would e
able vessels of deep draught to reach their wharves.

At Maumee bridge, where the town wharf is located, the river is 6
feet wide, with a depth of 4 to 5 feet of water, lowest stage since 18
It is thought well to state here that all my soundings are referred
lowest water since 1835, which is two feet and a half below ordina
low water. From the bridge to a point about 800 yards below, the ri
maintains a nearly uniform width, but the depth of water varies fro
to 7.8 feet. Bare rock forms the bottom, with here and there a thin c
ering of a few inches of sand and coarse gravel. From this point to E
ing's Island the water shoals rapidly to two feet and seven inches, (2.
Ewing's Island formerly divided the river into two branches of nea
equal capacity, that on the north side being the more direct and givi
the better water. In 1840–'41 a side-cut to the river was made from t
Wabash and Erie Canal, and an embankment to protect its debouc
was run across the north channel to what was then called Grape Isla
a small, triangularly shaped island, lying at the head of Ewing's Isla
and once forming a part of that island, but, at the time referred to, s
arated from it by a narrow water-way. The effect of this embankme
was to destroy Grape Island almost completely, and to fill up the no
channel. All that remains of Grape Island in the south channel is
low gravelly shoal that connects with the small remaining part of W
Club. This shoal is about 1,000 feet in length by 100 in width. and
visible at low water. The south channel runs between the shoal a
Ewing's Island, and has an average width there of 200 feet, and
average depth of 3½ feet of water. Ewing's Island is oval shaped, 1,
yards in length and 900 in width; on the north side, for one-half
water-front of Maumee, the channel has been so contracted by accun
lation that it is little else than a deep marsh.

Borings were taken in both channels, and rock was found at no po
at a less depth than 6½ feet. Those especially interested in the pr
perity of Maumee desire to have the embankment protecting the
bouche of the canal cut removed, and the north channel dredged o
this work would require the removal, exclusive of the embankment,
44,000 cubic yards of sand, in a cut 6,000 feet long, 50 feet wide, a
4 feet deep. The embankment, which contains about 18,000 cubic yar
was constructed by the State, and as the filling of the north channel
due to it alone, its removal and the dredging of the injured chan
would seem to be a State affair. The south channel has good water
cept at and near the head of Ewing's Island, and I would recomme
that it be so improved that vessels drawing 8 feet can reach the wh
at Maumee at low stage. This will require the removal of 20,000 cu
yards of sand and gravel, in a cut 2,700 feet long, 50 feet wide, an
feet deep. The next point to which special attention was given w
Rocky Bar, one mile below Ewing's Island. It extends from Jenniso
Bend to Marengo Island, a distance of 2,000 yards; at the former po
the stream is 400 yards wide, and at the latter 800. Bare rock und
lies the channel from shore to shore for the entire distance, but near t
axis I have not found by soundings that it appears at a less depth th
6½ feet, low stage, and then only at one point. This bar is not an
struction to navigation, though it is frequently spoken of as such; v
sels drawing 8 feet find no difficulty in crossing it at ordinary low sta

Leaving Rocky Bar, the channel passes on north side of Maren
Island, and thence, with 7 to 8 feet of water, low stage, to Delaw

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Flats, one mile below. These flats consist of pure sand and gravel to a depth of 6 feet; below this, borings revealed rock. At this point the stream is very wide and contains a group of islands, six in number, four on the south side, and two on the north side. The shoalest water over the flats is found opposite Eagle Point. Good water for the passage of vessels drawing 8 feet can be obtained by the removal of 10,000 cubic yards of material, in a cut 3,000 feet long, 60 feet wide, and 1½ feet deep. From Delaware Flats to Toledo railroad bridge, a distance of three miles, the channel is wide and well marked, and there is sufficient water for a vessel drawing as much as 10 feet.

From the foregoing it will be seen that, in order to give full 8 feet of water, ordinary low stage, from Toledo railroad-bridge to the wharf at Maumee, Ohio, it will only be necessary to remove 20,000 cubic yards of sand and gravel from the south channel at Ewing's Island, and 10,000 cubic yards from Delaware Flats. It is believed that this material can be removed for 20 cents per cubic yard, which would make the total cost of the improvement $7,000, after allowing $1,000 for inspection and minor expenditures necessary in the prosecution of the word.

Respectfully submitted.

G. L. GILLESPIE,
Captain of Engineers.

RESURVEY OF MONROE HARBOR, MICHIGAN.

U. S. ENGINEER OFFICE, IMPROVEMENT OF HARBORS,
LAKE ERIE, WEST OF DUNKIRK, NEW YORK,
Buffalo, New York, November 17, 1871.

This survey, though commenced late in May, was not completed till the middle of September. My assistant, Mr. Enright, to whom the instrumental labor was intrusted, is my principal inspector at Maumee Bay, and as he is a most reliable and accurate surveyor, well acquainted, in addition, with the former improvements of Monroe Harbor, I deemed it best to place him in charge of the survey, with the instructions to execute it at such times as he could be well spared from his duties in Maumee Bay. By reason of certain delays and difficulties attending the prosecution of his duties at Maumee Bay, not necessary to detail here, he was unable to give this survey the prompt attention I had expected. This explanation I submit in extenuation of the delay in transmitting my report.

The town of Monroe, Michigan, is situated upon the south bank of the Raisin River, about three and one-half miles from the lake-shore by the present water communications. Raisin River is a tortuous, sluggish stream, without any appreciable natural current. After passing Monroe, in its course to Lake Erie, it traverses low, marshy grounds, covered with matted grasses and thick reeds, and cut up with numerous small streams or bayous, off-shoots from the main river, which, after following devious courses, reach the lake, north and south of the present entrance to the harbor, within a compass of three miles. The harbor, so to speak, is not a natural one at the principal mouth of the river, but is an artificial one, formed on the lake-shores one and one-half miles to the northward, and connected with the river one and one-half miles from its mouth by a canal running northeast and southwest, cut by the United States, and called the United States Ship-Canal. The entrance is protected on the north and south sides by the usual long wooden piers, that run directly into the lake on the prolongation of the

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canal, with a wide splay at the outer termini. The light-house, which marks the approach to the harbor, is situated upon the outer extremity of the north pier. The piers were built in 1834–'35, and extensively repaired in 1867. The ship-canal was constructed, it is believed, in 1843, and is 3,949 feet in length and 100 feet in width. Three thousand two hundred feet westward of the head of this canal is the mouth of another artificial water-way, called the Monroe City Canal, which shortens the channel by cutting across a narrow elbow of the river. It is 1,100 feet in length and 100 feet in width, and was constructed by the town of Monroe. Following the channel, the lower docks of Monroe are 1,100 yards from the head of the city canal.

The banks of the United States Ship-Canal are revetted with sheet-piling throughout their length, and it is believed that all this piling below water, or the greater part thereof, is sound; but in many places the part *above* water is very badly decayed, some of it being broken off at the water's edge; especially is this case near the head of the canal, where the banks are beginning to wash under the action of the river-current, influenced by strong winds, or of the accumulations of ice just previous to the opening of navigation.

No extensive repairs are deemed necessary, but it would be best to protect the head against further injury by extending the revetment into short flanks or wings on either side, and to renew the piles that are worthless and decayed at such points along the lines of revetment where the greatest weakness is discovered. A liberal estimate for these repairs will be $3,000.

Considering the very slight commerce of Monroe, and the unfitness of its harbor for a harbor of refuge for vessels engaged in the commerce of Lake Erie, I do not feel justified in recommending an increase of the depth of water in Raisin River proper, nor in either of the artificial water-ways. By improvement of 1869–'70, under charge of Major McFarland, United States engineer, a channel was made, giving 12 feet at low stage between piers of entrance, into and through United States Ship-Canal, and through lower bar near the head of this canal. An inspection of the accompanying map will show that an 11-foot low-stage channel obtains from the United States canal to and through Monroe City Canal, excepting over Cooley's Bar, where there is an average only of 8½ feet. To carry this depth of 11 feet to the lower wharves (see 2214 R. & H., 1871,) at Monroe, removing what may be necessary over Cooley's Bar, there will be required to be dredged 42,000 cubic yards of sand and gravel, which, at 30 cents per cubic yard, will amount to $12,600. The borings, indicated in red in the map, show that no rock will have to be contended with except near the southern extremity of Island No. 2, and confronting Sterling's wharf, in the town of Monroe. It is believed that this rock can be removed with the dipper of the dredge.

It is claimed that the construction of a new railroad from the West, terminating at Monroe, will give rise to such life and activity in the commerce of this port that an 11-foot channel to Monroe piers will be absolutely necessary to meet the wants of the community. Monroe is one of the oldest ports on the lake, but from causes inherent probably in the position of the harbor itself, it has seen its trade gradually decline, while its younger and more fortunate neighbors have grown uninterruptedly in wealth and commercial importance. Vast sums have been expended there from time to time without an adequate return, and I would not recommend the expenditure of any more money for increasing the depth of water in the Raisin River until the commerce of Mon-

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roe, now prospective only, has been so far developed as to show that the improvement asked is based upon some better claim than that of convenience.

RECAPITULATION.

To give an 11-foot channel (low stage) from piers of entrance at light-house to Monroe wharves, and to make necessary repairs to revetment of the United States Ship-Canal:

42,000 cubic yards of sand required to be dredged for a channel 100 feet wide, at 30 cents	$12,600 00
Repairs to United States Ship-Canal	3,000 00
Total	15,600 00

Dredging not recommended.
Respectfully submitted.

G. L. GILLESPIE,
Captain of Engineers.

D 17.

IMPROVEMENT PROPOSED FOR BLACK RIVER HARBOR, OHIO.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, March 25, 1872.

Inside of the inner end of Government piers, the water of Black River varies from 15 to 24 feet, low stage, more than sufficient for the largest coal and iron vessels that navigate Lake Erie; but at the entrance to the harbor, extending 200 to 300 feet outwards, the water is reduced to an average of 10 feet. This harbor will, I am reliably informed, be connected during the summer by a railroad with the coal-fields in the interior of the State, and Black River will be made not only a large shipping point for coal, but also a place for the manufacture of iron.

For the accommodation of the coal and iron vessels of deep-draught which will be drawn to this harbor in consequence of the construction of the railroad, and to make the harbor a secure and protected harbor of refuge for large vessels, the entrance should have not less than 14 feet, low stage. This can be best obtained by extending the piers to the 14-feet curve, and by dredging out the inclosed channel. The length of piering required will be about 900 feet.

The channel next to the east pier on the inside has been greatly contracted by a filling of sand and gravel, supposed to have been washed over and from the east pier. The unexpended balance of the last appropriation will be ample to remove this material, and to make necessary repairs to the piers.

The extension of the piers will cost as follows:

900 linear feet of piering, at $60	$54,000
3,000 cubic yards of dredging, at 30 cents	6,000
Inspection, &c	1,000
Total	61,000

The improvement is recommended.

Very respectfully,

G. L. GILLESPIE,
Captain of Engineers, Brevet Lieutenant-Colonel, U. S. A.

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D 18.

GRAND RIVER HARBOR.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, January 15, 1872.

GENERAL: I have the honor to forward herewith a sketch of Grand River Harbor, Ohio, showing the depth of water in the channel, as determined by soundings taken the 5th instant. It is shown by the sketch that the deposit of sand in the channel inclosed between the flare of the west pier and the extremity of the east pier has been rapid, and that the entrance to the harbor for vessels of deep draught is thrown well over to the east side and around the east pier-head, and is very narrow. This bar closing the entrance, must be due to the direction given to the extremity of the west pier, the prevailing winds being from the southwest. I would recommend that the flare be removed, and that the west pier be extended into the lake 360 feet parallel with the east pier. This will about equalize the length of the two piers, and though the pier-head of the west pier extension will be extended but slightly beyond the prolongation of the shore-line on that side, it is believed that the removal of the flare will modify the beach in some degree, and that the proposed improvement will meet all demands of the next five years.

I also send herewith plans, &c., of the proposed pier extension. The unexpended balance for the harbor is $30,372; the estimated cost of the improvement, as shown in statement accompanying this letter, is $21,716.

It is recommended to invite proposals for this work, and to make the necessary contracts without undue delay, so that the improvement may commence as early as practicable after the opening of the navigation of the lakes.

Form of proposals are inclosed herewith.

Very respectfully, general, your obedient servant,

G. L. GILLESPIE,
Captain of Engineers.

Brigadier-General A. A. HUMPHREYS, U. S. A.,
Chief of Engineers, U. S. Army, Washington, D. C.

D 19.

GRAND RIVER HARBOR.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, January 27, 1872.

GENERAL: I have the honor to acknowledge the receipt of yours of 23d instant, asking my views relative to the improvement of Grand River Harbor, Ohio. I will answer your questions in their regular sequence.

1st. Extension of the west pier, parallel to east pier, commencing at outer extremity of the flare. This extension would require a corresponding extension of the east pier to make the entrance easy and safe at all seasons of the year, otherwise a short "chopping" sea, most trying to sailing vessels, would be formed within the pier-heads, as far back as the flare-angle, under a northeast wind, by the return-waves that strike the flare and its extension. The effect of windening the entrance

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to the channel between the piers, or of keeping it in its present enlarged state, is to partially check the scouring effect of the river and to encourage the formation of shoals just outside of the throat, (narrowest point of channel,) in a direction following the direction of the widening, and when the pier-head on that side is passed the littoral waves, from the side of prevailing winds, will carry the shoal across the channel, trending northward and eastward, and will finally close the entrance, or make it of very difficult access. This is exemplified in the harbor of Grand River to-day. The least effective extension would be 220 feet for the west pier, and 240 feet for the east, in all 460 feet, at a cost of $27,000.

2d. Inclining the west pier extension toward the east pier, commencing at the outer end of flare. In executing a work of this nature, the least admissible angle with the flare would require an east pier extension of 370 feet, and of the west pier 400 feet, in all 770 feet, at a cost of $46,000.

Besides the ungainly sight of the work and the cost by which it is obtained, the scouring effect of the river would be still more checked than in the case just considered. The pocket formed just inside the pier-heads would rapidly shoal, and would be continually subject, even under moderate winds, to high seas, most dangerous to mariners endeavoring to make the harbor, and the best handling of vessels would scarcely prevent disasters. In my judgment the true plan of improvement consists in the entire removal of the superstructure of the flare of the west pier, and in the extension of that pier directly into the lake on the prolongation of the inshore part, keeping parallel and of equal length with the east pier. In the plans already presented I contemplated only the extension of the west pier 360 feet, believing that when this was accomplished the bar at the entrance would be removed by the first spring freshet, and that the beach could not accommodate itself to the improvement to form a bar of permanent accretion under five years. Economy dictated the extent of the improvement recommended. It would be better to extend both piers to the general line of the ice-bar. This would require west pier extension 490 feet, and east pier 130 feet, in all 620 feet, at a cost of $37,000.

Very, respectfully, general, your obedient servant,

G. L. GILLESPIE,
Captain of Engineers.

Brigadier-General A. A. HUMPHREYS, U. S. A.,
Chief of Engineers, United States Army, Washington, D. C.

D 20.

GRAND RIVER HARBOR.

ENGINEER OFFICE,
Tompkinsville, Staten Island, February 13, 1872.

GENERAL: I beg leave to acknowledge the reference of the plan of improvement of Grand River Harbor, Ohio, proposed by Major G. L. Gillespie, Corps of Engineers, in his reports of 15th and 27th of January, 1872, accompanied by a tracing of a map of survey of a recent date, &c., for my views concerning the plan, and especially as to the effect that would probably be produced upon the channel of the river

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between the piers and the bar outside, in the event of its being adopt and carried out.

The plan of parallel piers, as adopted in general for the impro ment of lake harbors, is beyond question productive of the most fav able results.

The effect of such plan at Grand River would not prove an except to the usual result.

It is evident from the soundings on the recent survey that the b result possible has attended the prolongation of the east pier, the eff of which has been to prevent the spreading of the river-current to eastward; and there is good reason to believe that a further extens of the same pier is required to control the extent of the outside bar, a prevent its lapping over the entrance to the harbor. At present might be limited to a length nearly equal to the length of pier fr the beacon to the present end, say 360 feet or 400 feet. This should done prior to the commencement of any other work at this harbor.

The existing pier on the west side modifies the question of impro ment in some degree.

Objectionable as it may be as a weather-pier of this harbor, it nev theless subserves the purpose of a sand-catcher, for the littoral curre from the westward. A new pier on the dotted lines beginning at inner flare could not be more effectual in this respect.

The depth of water between the parallel portion of the piers is sin larly uniform, not varying materially from 14 feet, and the same gene depth is continued beyond the angle of the flare up to the extremity the east pier, where it begins to diminish slightly, and the direction the current trends to the eastward.

The tendency to this diminution of depth and to this change of di tion would be arrested by a further prolongation of the east pier, wh would, as already stated, prevent the spreading of the river-current the eastward, and thus control the position of the bar, or rather eastern end. The bar is formed by the sands washed around the end the west pier and by the sands drifted by the wind over the pier i the river and carried down its current. The latter, however, is belie to be small in proportion to the former.

There will inevitably be a bar in the vicinity of the west pier, m fied in position by the length and direction of the pier.

In the event of the west pier being entirely removed, and a new w pier built parallel to the east pier on the dotted lines on the tracing, bar would, as in all *similar* cases of lake harbors, form to the no ward and eastward with the same tendency to throw the channel of river toward the east.

This would be the result were the piers of equal extension tow the lake; the bar, however, having a direction approximating to angle of 45° with the direction of the west pier. In the case of west pier being built to a greater length than the east pier, the would assume a direction approaching to a right angle with the di tion of the pier.

The existing condition of the channel is not unfavorable for the trance of vessels of moderate draught of water. It is not certain tha more favorable condition of depth and direction would be secured any extension of the east pier and by a new parallel west pier, shor extending them out to the 14-feet curve beyond the bar, which wo require a length of 400 feet additional to the east pier, and of about feet of the west parallel pier, or nearly of these lengths to secur channel of not less than fourteen feet of water.

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In view, however, of the condition of the harbor, as shown on the tracing of the map of the recent survey, and of its preservation, it is advisable that the east pier be extended about 400 feet in its line of direction toward the lake.

At the same time it does not seem that the time has arrived for removing the flaring pier and for substituting a parallel pier. It is suggested that this period will arrive when the west pier becomes so decayed by time or weakened by the effect of storms as to require entire rebuilding, or by a more serious or more rapid accretion of the bar than is shown by the recent survey.

The papers inclosed in the letter of the Engineer Department are returned herewith.

Very respectfully, your obedient servant,

I. C. WOODRUFF,
Lieutenant Colonel of Engineers.

General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

D 21.

GRAND RIVER HARBOR.

Proceedings of a board of engineers, convened at Buffalo, New York, in pursuance of the following order:

[Special Orders No. 25.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 17, 1872.

1. A board of engineers, to consist of Lieutenant-Colonel I. C. Woodruff, Corps of Engineers; Major Walter McFarland, Corps of Engineers; Major J. M. Wilson, Corps of Engineers; Captain F U. Farquhar, Corps of Engineers; Captain G. L. Gillespie, Corps of Engineers, will assemble at Buffalo, New York, on the 26th instant, or as soon thereafter as practicable, to report a plan for the further improvement of the harbor of Grand River, Ohio.

The junior member of the board will act as recorder. * * *

By command of Brigadier-General Humphreys:

THOS. LINCOLN CASEY,
Major of Engineers.

The board met February 26, 1872, in pursuance of the above order; present, all the members.

All the papers bearing upon the question of the improvement of the harbor, presented by the president of the board and by the junior member, were read in the presence of the board, and the surveys of the harbor consulted in connection therewith. After mature deliberation, the board is of the opinion that the west pier should be extended 600 feet into the lake, parallel with the east pier, commencing on the inshore part of the flare-angle, and that the east pier be extended 300 feet.

The appropriation of $53,000, available for this harbor, will make these extensions, and it is thought that this improvement will meet all the present wants of commerce.

WALTER McFARLAND,
Major of Engineers.
JOHN M. WILSON,
Major of Engineers, United States Army.
F. U. FARQUHAR,
Captain of Engineers.
G. L. GILLESPIE,
Captain of Engineers.

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I agree fully with the board relative to the plan of improvement by straight parallel piers, but I am of opinion, for reasons presented in my report to the Chief of Engineers, dated February 13, 1872, that no more of the plan should be constructed at present than the prolongation of the east pier.

I. C. WOODRUFF,
Lieutenant-Colonel of Engineers.

There being no further business before the board, it adjourned *sine die.*

I. C. WOODRUFF,
Lieutenant-Colonel of Engineers.
G. L. GILLESPIE,
Corps of Engineers, Recorder.

APPENDIX E.

ANNUAL REPORT OF MAJOR F. HARWOOD, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDED JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, September 20, 1872.

I have the honor to transmit herewith my annual report upon the works under my charge, for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

F. HARWOOD,
Major Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

E 1.

IMPROVEMENT OF BUFFALO HARBOR, NEW YORK.

The interior works of improvement having been completed, operations were confined to the extension of the breakwater, and such necessary repairs of piers as were required to keep them in good condition. The north United States pier-head, damaged as mentioned in my last annual report, was thoroughly repaired and secured, and the bill of damages presented to the agent of the Union Steamboat Company's line, and turned over to the proper law authorities of the United States. Other minor measures were taken by hired labor to repair and secure work already built.

With regard to work in progress on the breakwater: At the close of the fiscal year ending June 30, 1871, 1,711 linear feet of under-water work had been laid, of which 1,183 feet had been completely covered with superstructure, leaving 528 feet incomplete. During the fiscal year 1871–'72, the 528 feet unfinished work was completely covered: there were added 425 feet of under-water work, and in superstructure complete 142 feet, leaving 283 feet unfinished. Thus, at the close of the fiscal year ending June 30, 1872, the breakwater stood: 2,136 feet

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under-water work laid, covered by 1,853 feet of superstructure complete, and 283 feet in an unfinished state. In all probability, at the close of the working-season of 1872, under the contract with D. E. Bailey, awarded by virtue of the Chief of Engineers' letter of July 1, 1872, the breakwater will stand: 2,387 feet under-water work laid, and covered by 2,084 feet of superstructure complete.

Owing to the yielding foundation upon which the remaining work has now to rest, it becomes necessary to allow cribs to settle under the influence of autumn gales, and the pressure of winter ice, until the succeeding spring, before it is prudent to place superstructure upon them. For this reason 303 feet of superstructure will be allowed to remain incomplete until the close of the fiscal year, when there probably will be reported 2,387 feet of the work finished. In this connection it is necessary for a full understanding of the work to state that during the last season it has passed from a firm foundation of sand and rubble, in which there has scarcely been any appreciable settling of cribs, to a soft clay stratum, in which, under the influence of heavy weather, cribs have settled within twenty-four hours as much as four feet, after having once been well placed in their bed. Therefore, taking into consideration the increasing depth of water, it is safe to estimate the cost of future work at 50 per cent. more than that which has been heretofore laid, taking into account leveling and the various other contingencies incidental to like construction.

Amount required for entire and permanent completion of the work:

Construction of breakwater	$600,000
Construction of proposed south channel	300,000
Total	900,000

Amount that can be profitably expended upon the work during the next fiscal year:

Construction of breakwater	$300,000
Contingencies of repairs and leveling	10,000
Commencement, construction of the proposed south channel	100,000
Total	410,000

Buffalo Harbor is located in the collection-district of Buffalo Creek, New York; is near Fort Porter, New York; has a light-house on south pier; a beacon at the north end of United States breakwater; and a beacon on the middle reef at entrance to the Niagara River.

Amount of revenue collected at Buffalo during the last fiscal year was $494,280.38.

Entrances and clearances for the last fiscal year, $10,105. Tonnage of same, 4,575,659 tons.

ABSTRACT OF CONTRACTS.

Contract dated June 28, 1871, with D. E. Bailey for furnishing all material and labor for construction of a section of the breakwater.

Pine and hemlock timber and lumber per thousand feet board-measure	$20 00
Wrought-iron drift-bolts, per pound	3½
Wrought-iron spikes, per pound	4½
Crib-framing, &c., per linear foot of timber	12
Superstructure, per linear foot of timber	12
Stone furnished and put in work, per cord	8
Plank joists, &c., fitting and fastening, per thousand board-measure	8

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Contract dated August 29, 1871, with D. E. Bailey, of Buffalo, New Y for materials and labor, repairs to north pier.

Pulling-piles, per pile	$
Furnishing and driving piles, per linear foot	
Furnishing, framing, bolting, and fastening oak timber and lumber, per thousand feet board-measure	6
Furnishing and putting in the work hard stone, per cubic yard	
Furnishing, driving, &c., straps, chains, bolts, screw-bolts, &c., per pound	

Statement of cash.

Amount on hand July 1, 1871	$10,05
Cash received during fiscal year	60,00
Cash expended during fiscal year	70,02
Amount available July 1, 1872	98,51
Amount required for fiscal year ending June 30, 1874	410,00

BUFFALO SEA-WALL.

The unexpended balance of old appropriations for this work transferred to the credit of Buffalo Harbor, in accordance with terms of the river and harbor appropriation bill, approved June 1872. This work of improvement is therefore closed.

E 2.

IMPROVEMENT OF DUNKIRK HARBOR, NEW YORK.

The prescribed improvements of this harbor were commenced building the day-beacon at the entrance of the harbor. This work completed and turned over to the custody of the light-house engineer of tenth light-house district, on the 30th July, 1872. Two hundred and feet of breakwater were laid, being as much as the amount of appropria would warrant. The foregoing operations, together with necessar pairs of the west United States pier, exhausted the appropriation, the work was therefore closed. As soon as navigation opened in it became evident that serious shoaling had taken place at the entr to the harbor, which, coupled with the fact of the water standin about a foot and one-half below the stage which had ruled for yea this season, rendered the harbor inaccessible to vessels of even mo ate draught. Immediate measures of relief were therefore neces and accordingly, as soon as the appropriation for 1872–'73 became a able, I hired a dredge and began to open the approach to the harbo deavoring to get the depth of water (13 feet) prescribed by the boa engineer officers of November 30, 1870. This work was in progress a close of the fiscal year. During the present working-season 60 feet be added to the breakwater, and, in the spring of 1873, 90 feet m making in all 150 feet, adding which to the 210 feet built last year give 360 feet of work completed at the close of the fiscal year 1872 This, together with the expense of dredging, (completed Septemb 1872,) will exhaust the appropriation, and the work will be closed another becomes available.

In surveying for the site of the breakwater it became evident the map of 1866, upon which the board of 1870 based its decisions, in error in several essential points. I therefore caused a thorough

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survey of the harbor from headland to headland to be made, and will shortly lay before the Chief of Engineers the result in a complete map, showing the actual state of the harbor up to September 1, 1872. A study of this map, together with soundings to be taken next spring, will throw light on the serious matter of the shoal-formation at the mouth of the harbor, which has greatly increased since the completion of the west United States pier. Its removal during the present working-season cost $4,710 in dredge-hire, and if it should again rapidly form it may become a question whether some other expedient would not be more economical in the end than annual dredging. This I shall discuss in due time, after soundings have been taken in the spring of 1873 over the area dredged in 1872.

The result of the resurvey of the harbor will probably modify considerably the estimates of the board of 1870. They are, however, retained in this report in the absence of any data for a change.

Amount required for entire and permanent completion of the work:

Construction of breakwater	$266,000 00
Blasting and dredging for channel	40,000 00
Total	306,000 00

Amount that can be profitably expended upon the work during the next fiscal year:

Construction of breakwater	$100,000 00
Blasting and dredging channel	40,000 00
Contingencies	10,000 00
Total	150 000 00

Dunkirk Harbor is located in the collection-district of Dunkirk, New York, has a light-house on the main-land, and a beacon at the end of the west pier.

Amount of revenue collected at Dunkirk, New York, during the last fiscal year, was $2,770.

Entrances and clearances for the last fiscal year, 93; tonnage of same, 15,876 tons.

Abstract of contract, dated June 8, 1871, with O. J. Jennings, of Syracuse, New York, for labor, and timber, and lumber.

Hemlock timber, per thousand feet, board-measure	$22 00
Pine timber and lumber, per thousand feet board-measure	25 00
Oak timber and lumber, per thousand feet board-measure	45 00
Framing, &c., crib-work, per linear foot, timber	16
Framing, &c., superstructure, per linear foot, timber	22
Stone furnished and put in work, per cord	10 00
Fitting, fastening, &c., planks, joists, &c., per thousand feet board-measure	15 00

Statement of cash.

Amount on hand July 1, 1871	$11,862 77
Cash received during fiscal year	13,000 00
Cash expended during fiscal year	24,639 69
Amount available June 30, 1872	25,223 08
Amount required for fiscal year ending June 30, 1874	150,000 00

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APPENDIX F.

ANNUAL REPORT OF MAJOR JOHN M. WILSON, CORPS O
ENGINEERS, FOR THE FISCAL YEAR ENDED JUNE
1872.

UNITED STATES ENGINEER OFFICE,
Oswego, New York, July 19, 1872

GENERAL: I have the honor to submit the annual report of t
works of improvement under my charge for the fiscal year ended Ju
30, 1872.

I am, general, very respectfuly, your obedient servant,
JOHN M. WILSON,
Major of Engineers, U. S. A

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

F 1.

OLCOTT HARBOR, NEW YORK.

The opening of the fiscal year found operations in progress upon
piers under contract with J. D. Cooper, of Olcott, New York.

During the season, four cribs, 30 feet by 20 feet, and one 20 feet
20 feet, of an average height of 9½ feet, were added to the east pier, a
three cribs, 30 feet by 20 feet, of the same height, to the west p
making the total length of crib-work sunk 230 feet; 160 linear feet
superstructure of an average height of 4 feet was constructed on the e
pier, and 198 linear feet upon the west pier; 215 feet on the east and
feet on the west pier were filled with stone and covered with deck-pla
The total length of the east pier is now 731 feet, and of the west 1,
feet.

During the present-working season it is proposed to construct
linear feet of crib-work, adding 120 feet to each pier; the superstruct
will be built in the spring of 1873.

In June, 1872, a resurvey of the harbor was made with borings
determine the character of the bottom; this survey shows that an
tensive bed of rock underlies the sand and gravel; this bed exte
entirely across the channel between the piers, is 280 feet long, and sh
a depth upon it of about 7½ feet at ordinary low water; to obtai
channel 150 feet wide will necessitate the excavation of 7,606 cubic ya
of rock, and 10,327 cubic yards of sand, gravel, clay, and loose stones

Olcott is a port of entry in the collection-district of Niagara.

The nearest fort is Niagara, eighteen miles to the westward, and
nearest light is at the fort.

The amount of revenue collected during the fiscal year was $842.68
gold and $57.40 in currency. The value of the imports was $9,520.

Forty-eight vessels, with an aggregate tonnage of 2,303 tons, ente
and cleared, and six vessels entered for shelter during the year.

Amount available July 1, 1871	$5,490
Amount expended during the year	5,490
Amount available July 1, 1872	10,000
Amount required for the fiscal year ending June 30, 1874, to complete the piers, excavate a channel through the rock, and inside the harbor	50,000

Abstracts of contracts in force are transmitted herewith.

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Abstract of contracts for improvements of Olcott Harbor, New York, in force during the fiscal year ended June 30, 1872.

Names of contractors.	Residence.	Date of contract.	Subject of contract.	Remarks
J. D. Cooper	Olcott, N. Y.	May 22, 1871	Stone	Contract closed Oct. 11, 1871.
J. D. Cooper	Olcott, N. Y.	May 22, 1871	Labor	Contract closed Oct. 11, 1871.

Abstract of contracts, with contract-prices, for each class of materials and labor for improvement of Olcott Harbor, New York, in force during the fiscal year ended June 30, 1872.

Names of contractors.	Residence.	Date of contract.	Stone.		Labor.			
			Handling U. S. stone.	Furnishing stone.	Counter-hewing timber.	Timber-work.	Driving iron.	Driving treenails.
			Per cord.	*Per cord.*	*Per lin. ft.*	*Per 1000 ft. b. m.*	*Per lb.*	*Per 100.*
J. D. Cooper	Olcott, N. Y.	May 22, 1871	$1 50	$6 00	.....	.....	.....	.....
J. D. Cooper	Olcott, N. Y.	May 22, 1871	.....	.....	$0 01½	$6 00	$0 01	$3 00

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F 2.

OAK ORCHARD HARBOR, NEW YORK.

The opening of the fiscal year found operations in progress upon the piers, under contract with H. J. Mowry, of Syracuse, New York.

During the season five cribs, 30 feet by 20 feet, of an average height of 9¾ feet, were added to the east pier, and four similar in size, were added to the west pier, making the total length of crib-work sunk, 270 feet; 160 feet of superstructure complete was constructed on the east, and 190 feet on the west pier, the average height being 4½ feet; 340 feet of superstructure on the east and 269 on the west pier were filled with stone and covered with deck-plank.

The total length of the east pier is now 915 feet, and of the west pier 1,134½ feet. The depth off the end of the piers at mean low water is 11½ feet, and it is not deemed advisable to continue them any further for the present, as the depth remains the same for some distance.

On the 25th of August, 1871, operations were commenced with dredges, deepening the channel between the piers, under contract with E. H. French, of Fulton, New York, who was to remove 30,000 cubic yards by November 15, 1871.

The material at the bottom proved to be a very stiff clay, mingled with gravel, cobble-stones, stone washed out of the piers, &c., overlying an extensive bed of red sandstone; although Mr. French labored industriously, he met with many serious interruptions from storms and breakage of machinery, and was able to work only two hundred and eighty-three hours between August 25 and November 15, when navigation closed; during this period he removed 7,656.22 cubic yards of material, measured in scows. His time having expired, his contract was closed, but, on account of the circumstances of the case, no action was taken, other than to declare the reserved percentage forfeited to the United States.

In the spring of 1872 an accurate survey was made upon the ice, borings were made over the entire channel, and it was found that a bed of red sandstone extended entirely across between the piers, giving various depths upon it. The report of Mr. W. P. Judson, transmitted herewith, explains in full the operations connected with the survey. In this, as in all the duties to which he has been assigned, he has shown the same good judgment, care, and attention.

A careful estimate of the material in position shows that, in order to obtain a channel 150 feet wide between the piers, and 12 feet deep at mean low water, it will be necessary to remove 10,988 cubic yards, in position, of stiff clay mingled with cobble-stones, &c., and 7,854 cubic yards of red sandstone.

In April, 1872, proposals were invited for removing all the materials in the channel, except rock, to a depth of 12 feet at mean low water. But one bid was received, that of Mr. E. H. French, of Fulton, New York, at 75 cents per cubic yard, and the work was awarded to him. He commenced operations June 13, 1872, but the dredging was so difficult that by June 30 he had removed only 761.58 cubic yards, measured in scows.

During the present season it is proposed to make a few minor repairs upon the piers, and to remove, if possible, all the material from the channel between the piers, except rock, to a depth of 12 feet at mean low water.

Amount available July 1, 1871	$15,724 37
Amount expended during the year	9,484 39

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Amount available July 1, 1872	8,739 98
Amount required for the fiscal year ending June 30, 1874	30,000 00

It is estimated that this amount will clear the channel to the proper depth and repair the piers where necessary.

Oak Orchard is a port of entry in the collection-district of Genesee.

The nearest fort is Niagara, forty-five miles distant. A fixed white light of the fourth order has been placed at the outer end of the west pier.

The amount of revenue collected during the year was $3,500 in gold, and $200 in currency. The value of the imports was $25,000; the value of the exports $140,000. Seventy vessels entered and cleared during the year, the aggregate tonnage each way being 5,804 tons.

Abstracts of proposals and of contracts are transmitted herewith.

UNITED STATES ENGINEER OFFICE,
Oswego, New York, April 4, 1872.

MAJOR: I have the honor to report that, in accordance with your instructions of March 26, I have made a survey of Oak Orchard Harbor, the results of which I respectfully submit in the accompanying map.

This survey was made to ascertain the location and extent of a ledge of rock lying across the entrance of the harbor, and also to determine the character and amount of overlying material to be removed to obtain the desired channel. This was done by boring through the deposit; the depth at which rock was found, and the character of the material covering it, being noted. A drill was used for this purpose, as it was found to work more rapidly than an auger, and to give the character of the material more readily. The latter was determined by the rate of penetration, and although through hard material this was sometimes very slow, still when the rock or a bowlder too large to yield was reached, it was at once made apparent by the recoil of the drill from each blow of the drivers. The rock being of a very soft character as shown by the accompanying specimen, it allowed the chisel-edge of the drill to penetrate it in one or two blows, sufficiently to prevent its being turned; in this respect differing from the bowlders, for they, being much harder, resisted the drill and allowed it to be turned readily after any number of blows. In the latter case, the drill was withdrawn and another boring made a few feet off, when rock was usually found at a slightly greater depth.

I give below the amount of rock and other excavation necessary to obtain a channel 150 feet wide, with 12 feet depth at mean water level, or 9¾ feet below zero of gauge, extending from the lake to the basin inside, a distance of 1,300 feet.

The total amount of excavation was ascertained by calculating the areas inclosed by the different foot horizontals of the surface of the material to be removed. This was then divided into horizontal sections of one foot altitude, having these areas for their upper and lower bases. The mean of these bases being taken as the base of a prism of the same altitude, the volume of each section was computed. The amount of rock was found in the same manner. Total amount of excavation, 18,822 cubic yards; amount of rock, 7,834 cubic yards; amount of deposits, 10,988 cubic yards.

I am, major, very respectfully, your obedient servant,

WM. P. JUDSON.

Major JOHN M. WILSON,
Corps of Engineers, U. S. A.

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Abstract of contracts, with contract-prices, for each class of materials and labor for impr ment of Oak Orchard Harbor, New York, in force during the fiscal year ended Jun 1872.

Names of contractors.	Residence.	Date of contract.	IRON.			STONE.	
			Screw and washer bolts.	Drift-bolts.	Spikes.	Furnishing stone.	Handling U. S. stone
			Per lb.	*Per lb.*	*Per lb.*	*Per cord.*	*Per c*
E. H. French.....	Fulton, N. Y ..	May 22, 1871	.....	.....	.....	.....	.....
Henry J. Mowry.	Syracuse, N.Y.	May 27, 1871	$0 06½	$0 04½	$0 06½	$6 50	.....
Henry J. Mowry.	Syracuse, N.Y.	May 27, 1871	.....	.....	.....	.....	.....
E. H. French.....	Fulton, N. Y ..	May 23, 1872	.....	.....	.....	.....	.....

Names of contractors.	Residence.	Date of contract.	LABOR.					
			Towing and sinking cribs.	Counter-hewing timber.	Timber-work.	Driving iron.	Driving tree-nails.	
			Per crib.	*Per lin. foot.*	*Per 1,000 ft. b. m.*	*Per lb.*	*Per 100.*	*Per*
E. H. French.....	Fulton, N. Y ..	May 22, 1871	.....	.....	.....	.....	.....	
Henry J. Mowry.	Syracuse, N.Y.	May 27, 1871	.....	.....	.....	.....	.....	
Henry J. Mowry.	Syracuse, N.Y.	May 27, 1871	$50 00	$0 03	$5 50	$0 0½	$8 00	.....
E. H. French.....	Fulton, N. Y .	May 23, 1872	.....	.....	.....	.....	.....	

Abstract of proposals for dredging at Oak Orchard Harbor, New York. Proposal o by Major John M. Wilson, Corps of Engineers, May 17, 1872.

No.	Names of bidders.	Residence.	Dredging 13,000 cubic yards, more or less.		Rem
			Price per cubic yard.	Amount.	
1	E. H. French	Fulton, N. Y ..	75 cents.....	$9,750	Awa

Abstract of contracts for improvement of Oak Orchard Harbor, New York, in force d the fiscal year ended June 30, 1872.

Names of contractors.	Residence.	Date of contract.	Subject of contract.	Remarks.
E. H. French...	Fulton, N. Y ..	May 22, 1871	Dredging	Contract closed January 5.
H. J. Mowry ...	Syracuse, N. Y.	May 27, 1871	Materials and labor.	Contract closed October 11.
H. J. Mowry ...	....do	May 27, 1871	Labor.....	Do.
E. H. French...	Fulton, N. Y ..	May 23, 1872	Dredging	

F 3.

CHARLOTTE HARBOR, NEW YORK.

The depth of water in the harbor being sufficient, and the piers erally in fair condition, operations during the season of 1871 were fined to such minor repairs as were absolutely necessary. One hund feet of the outer end of the west pier was covered with deck-pla and 58 places at various points on the piers were repaired. The

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timber on hand was piled and sorted, and the Government store-house moved off of private lands to a more convenient position.

In December, 1871, proposals were invited for removing the old decayed superstructure from 800 feet, more or less, of the west pier, and replacing it with new materials. The bids were opened January 15, 1872, and the work awarded to Mr. James McLean, of Troy, New York. After much delay and trouble, Mr. McLean gave proper bondsmen, and the contract was executed.

In accordance with its terms, he was to have commenced operations on or before April 15, 1872. He did go through the form of beginning on that day, by tearing up a few planks, but from that time until early in June his operations amounted to but little, and we were obliged to submit to considerable unnecessary delay and annoyance, owing to the fact that he had procured no timber for his work. Early in June, however, he obtained materials, and by June 30 had succeeded in about completing 90 linear feet of superstructure, and partially completing 90 additional feet. During the present working-season it is proposed to entirely remove 700 feet more of the old superstructure, and to replace it with new materials.

Charlotte is a port of entry for Rochester, six miles south of it. There is a fixed white light of the fourth order on shore, and a beacon with a fixed white light of the sixth order on the west pier.

The nearest fort is Ontario, sixty miles distant.

Amount available July 1, 1871	$12,858 33
Amount received for sale of timber to Pultneyville Harbor	666 40
Amount expended during the year	2,196 08
Amount available July 1, 1872	11,328 65

Amount required for the fiscal year ending June 30, 1874, nothing.

The amount of revenue collected for the fiscal year was $96,931.89; the value of the imports was $611,775; 559 vessels, with an aggregate tonnage of 64,400 tons, entered, and 547, with an aggregate tonnage of 94,781 tons, cleared, during the year.

Abstracts of bids with names of bidders, and abstracts of contracts, are transmitted.

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Abstract of proposals for furnishing materials and labor at Charlotte Harbor, N. Y., opened by John M. Wilson, major Engineers, U. S. A., January 15, 1872

Number.	Names of bidders.	Residence.	CLASS I.—TIMBER AND PLANK.									CLASS II.—IRON.	
			159,600 feet pine timber, b. m.				Pine plank, 40,200 feet b. m., 20′ × 3″ × 9″ to 15″.		Snubbing-posts, 276 linear feet, or 3,532 feet b. m.				Drift-bolts, 24,750 pounds.	
			77,040 feet b. m. 30′ × 12″ × 12″.		82,560 feet b. m. 20′ × 12″ × 12″.									
			Pr. M. ft. b. m.	Total.	Pr. M. ft. b. m.	Total.	Pr. M. ft. b. m.	Total.	Per lin. foot.	Pr. M. ft. b. m.	Total.	Total class I.	Per lb.	Total.
1	Henry J. Mowry	Syracuse, New York	$26 00	$2,003 04	$26 00	$2,146 56	$26 00	$1,045 20	.....	$26 00	$91 83	$5,286 63	$0 04¾	$1,175 62
2	James McLean	Troy, New York	20 00	1,540 80	20 00	1,651 20	20 00	804 00	.....	45 00	158 94	4,154 94	0 05¼	1,361 25
3	Charles H. Moore	Albion, New York	30 00	2,311 20	30 00	2,476 80	30 00	1,206 00	$0 50	.....	138 00	6,132 00	0 05	1,237 50
4	James Caldwell	Fulton, New York	26 50	2,041 56	25 50	2,105 22	25 00	1,005 00	0 80	.....	220 80	5,372 64	0 05	1,237 50
5*	Thomas Parsons	Rochester, New York	24 00	1,848 96	24 00	1,981 44	23 00	924 60	0 40	.....	110 40	4,865 40	0 05	1,237 50
6	E. H. French	Fulton, New York	27 00	2,080 08	27 00	2,229 12	27 00	1,085 40	1 00	.....	276 00	5,670 60	0 05¼	1,361 25
7	Samuel G. Hart	....do	31 00	2,388 24	31 00	2,559 36	31 00	1,246 20	.....	31 00	109 49	6,303 29	0 03	742 50
8*	Fuller & Marshall	Albany, New York	27 00	2,080 08	27 00	2,229 12	28 00	1,125, 60	0 65	.....	179 40	5,614 20	0 07	1,732 50

Number.	Names of bidders.	Residence.	CLASS II.—IRON—Continued.			CLASS III.—LABOR.							Whole work, grand total.
			Spikes, 2,300 lbs.		Total class II.	Moving stone, taking out and replacing 350 cords.		Timber work, 266,000 feet b. m.		Iron work, 28,700 pounds.		Total class III.	
			Per lb.	Total.		Pr. cord.	Total.	Pr. M. ft. b. m.	Total.	Per lb.	Total.		
1	Henry J. Mowry	Syracuse, New York	$0 05½	$126 50	$1,302 12	$4 75	$1,662 50	$9 50	$2,527 00	$0 01½	$430 50	$4,620 00	$11,208 75
2	James McLean	Troy, New York	0 05½	126 50	1,487 75	1 42	497 00	8 00	2,128 00	.....	....(†) ...	2,625 00	8,267 69
3	Charles H. Moore	Albion, New York	0 05	115 00	1,352 50	1 25	437 50	5 00	1,330 00	0 01	287 00	2,054 50	9,539 00
4	James Caldwell	Fulton, New York	0 06½	143 75	1,381 25	2 40	840 00	10 25	2,726 50	.....	....(‡) ...	3,566 50	10,320 39
5*	Thomas Parsons	Rochester, New York	0 05½	126 50	1,364 00	1 90	665 00	.....	16 00	.....	.....	.....	.....
6	E. H. French	Fulton, New York	0 10	230 00	1,591 25	3 50	1,225 00	11 00	2,926 00	.....	....(‡) ...	4,151 00	11,412 85
7	Samuel G. Hart	....do	0 03	69 00	811 50	3 00	1,050 00	12 50	3,325 00	0 02	574 00	4,949 00	12,063 79
8*	Fuller & Marshall	Albany, New York	0 08	184 00	1,916 50	4 50	1,575 00	.....	14 95	.....	.....	.....	.....

*Bids not made in accordance with specifications as required; under class III at so much per linear foot of pier instead of so much per M. foot b. m. as called for.
† Per linear foot of pier. Informal. ‡ Included in price for timber-work.
OSWEGO, NEW YORK, *January* 15, 1872.

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Abstract of contracts, with contract-prices, for each class of materials and labor, for improvement of Charlotte Harbor, New York, in force during the fiscal year ended June 30, 1872.

Name of contractor.	Residence.	Date of contract.	Timber.		Iron.		Labor.	
			Pine timber and plank.	Snubbing-posts.	Drift-bolts.	Spikes.	Taking out and replacing stone in superstructure.	Timber and iron-work.
			Per M. ft. board measure.	*Per M. ft. board measure.*	*Per lb.*	*Per lb.*	*Per cord.*	*Per M. ft. board measure.*
James McLean	Troy, N.Y.	Feb. 22, 1872	$20 00	$45 00	$0 05½	$0 05½	$1 42	$8 00

Abstract of contracts for improvement of Charlotte Harbor, New York, in force during the fiscal year ended June 30, 1872.

Name of contractor.	Residence.	Date of contract.	Subject of contract.
James McLean	Troy, N. Y.	Feb. 22, 1872	Materials and labor.

F 4.

PULTNEYVILLE HARBOR.

The opening of the fiscal year found operations in progress upon the west breakwater, under contract with H. J. Mowry, of Syracuse, New York.

Six cribs, 30 feet by 20 feet, of an average height of 9½ feet, were constructed, and, after the bottom had been properly dredged for foundation, were sunk upon the prolongation of the old pier on the west side of the harbor; a superstructure averaging four feet high was built upon the cribs, thus completing 180 linear feet of pier.

The outer end showing a tendency to sink, it was protected by a riprap to prevent the washing away of the sand.

During the present season, it is proposed to construct 210 feet of an east pier, commencing at a point 200 feet from the end of the pier completed last season, and on the prolongation of its line, and running in toward shore, so as to form a protection for vessels during a northeasterly or an easterly gale.

The cribs will be constructed on the Oswego model, slightly modified; the pier will be 20 feet wide.

The project for this harbor consists of the breakwater already built, a west pier 290 feet long, running north from the outer end of the breakwater, an east pier 425 feet long and parallel to the west pier, and 200 feet from it, and the dredging of the harbor by removing 25,000 cubic yards of material measured in position.

Amount available July 1, 1871	$8,976 49
Amount expended during the year	8,976 49
Amount available July 1, 1872	10,000 00
Amount required for the fiscal year ending June 30, 1874, to complete the work	31,500 00

Pultneyville is a port of entry in the collection-district of Genesee.

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The nearest fort is Ontario, forty-two miles to the east, and the nearest light is at Big Sodus, twelve miles distant.

The amount of revenue collected during the fiscal year was $1,142.30. The aggregate amount of tonnage of the vessels entering and clearing was 7,064 tons.

An abstract of contracts in force during the fiscal year is transmitted.

Abstract of contracts for improvement of Pultneyville Harbor, New York, in force during the fiscal year ended June 30, 1872.

Name of contractor.	Residence.	Date of contract.	Subject of contract.	Remarks.
H. J. Mowry.....	Syracuse, N. Y..	June 9, 1871	Materials and labor.	Contract closed Sept. 30, 1871.

Abstract of contracts, with contract prices, for each class of materials and labor, for improvement of Pultneyville Harbor, New York, in force, during the fiscal year ended June 30, 1872.

Name of contractor.	Residence.	Date of contract.	TIMBER.			IRON.			STONE	LABOR.		Dredging.
			Hemlock timber & plank.	Pine timber and plank.	Snubbing-posts.	Screw and washer bolts.	Drift-bolts.	Spikes.	Furnishing.	Timber-work.	Driving iron.	
			Per M ft., b. m.	Per M ft., b. m.	Per linear foot.	Per pound.	Per pound.	Per pound.	Per cord.	Per M ft., b. m.	Per pound.	Per cubic yard.
H.J. Mowry	Syracuse, N. Y.	June 9, 1871	$21 00	$30 00	$0 50	$0 06½	$0 04½	$0 06½	$6 50	$5 00	$0 01	$0 85

F 5.

BIG SODUS HARBOR, NEW YORK.

No appropriation having been made for this harbor, no operations for its improvement have been carried on.

In April, 1872, a small amount of timber, equal in value to the available funds, was ordered for the piers.

In June a resurvey of the harbor was made in order to deduce the cubic contents in position to be removed by dredging.

Big Sodus is a port of entry in the collection district of Oswego. There is a fixed white light varied by flashes, of the fourth order, at this place, and two beacon-lights as ranges for the pier.

Fort Ontario is the nearest work of defense. During the present season it is proposed to commence dredging a channel between the piers, to be 200 feet wide by 12¼ feet deep at mean low water, containing 29,596 cubic yards in position, and also to build up and repair such portion of the east breakwater as the funds on hand will admit.

Amount available July 1, 1871	$1,224 18
Amount expended during the year	41 67
Amount available July 1, 1872	16,182 51
Amount required for the fiscal year ending June 30, 1874	30,000 00

Which will complete the dredging of the entire channel between the piers, finish the east breakwater, and renew all decayed superstructure.

The amount of revenue collected during the year was $447.37; the

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value of the imports was $2,172.30; the number of vessels entered was 56, with an aggregate tonnage of 4,180 tons, and the number cleared was 72, with an aggregate tonnage of 5,763 tons.

F 6.

LITTLE SODUS HARBOR, NEW YORK.

Operations were commenced July 6, 1871, under contract with Mr. E. H. French, of Fulton, New York.

During the season of 1871 the west pier, which had partially tipped over on the channel side, was raised to the proper level, and replanked for a distance of 350 feet. It was not deemed advisable to put in any more stone, it being desirable to increase the weight on the east side the least possible.

The breakwater joining the west pier with the shore was entirely rebuilt for a distance of 250 feet, and partially rebuilt for an additional distance of 90 feet, completing the connection with the shore in a substantial and satisfactory manner. In the construction of this breakwater three cribs, built in 1868, and all the old timber on hand were used. A pier-head, for a beacon-light 30 feet square, was constructed and sunk at the end of the pier in water 14 feet deep, and a superstructure 7 feet high built upon it; on this the Light-House Department have this season constructed a beacon.

On July 25, 1871, operations were commenced with two dredges, excavating a channel parallel to the pier. This channel was made 200 feet wide, 12 feet deep at mean low water, and 1,200 feet long. At the inner end a bar was found that had been formed by the sand being washed in through the breach in the old breakwater. In dredging this channel, 22,625 cubic yards of gravel, sand, and mud were removed. Operations were suspended October 15, 1871.

In January, 1872, proposals were invited for furnishing hemlock and pine timber for an east pier, to be constructed this season. On February 6 the pine was awarded to Messrs. Post & Henderson, of Oswego, New York, and the hemlock to Mr. C. J. De Graw, of Fulton, New York, their contracts requiring the delivery of the materials by June 20, 1872. Messrs. Post & Henderson have delivered the amount of pine called for, (62,760 feet, board measure,) but Mr. De Graw has not as yet furnished any hemlock. At his request, the Department has extended the time of final delivery to August 1, 1872.

During the present working-season it is proposed to construct 420 feet of an east pier, 250 feet from and parallel to the west pier. The work will be built of cribs after the Oswego model, modified.

Little Sodus is a port of entry in the collection district of Oswego. Fort Ontario, fifteen miles distant, is the nearest work of defense. A fixed white light of the fourth order has been placed on the outer end of the pier this season.

Amount available July 1, 1871	$15,352 19
Amount expended during the year	12,603 58
Amount available July 1, 1872	17,748 61
Amount required for the fiscal year ending June 30, 1874	45,000 00

I have received from the deputy collector at Little Sodus, New York, the following statistics for that port:

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Amount of revenue collected, $142.68; value of imports for fiscal year, $3,600; number of vessels entering, 56.

Exports for fiscal year about 4,000 tons of iron, 350 cords of wood, and 350,000 feet, board measure, of lumber.

Abstracts of proposals and contracts are transmitted herewith.

Abstract of bids for furnishing timber for Little Sodus Harbor, New York, opened February 6, 1872, by James S. Lawrence, civil assistant engineer, by order of Major John M. Wilson, Corps of Engineers, the latter being confined to his house by illness.

	Name of bidders.	Residence.	CLASS I.—HEMLOCK TIMBER. 148,200 ft., b. m.				
			84,600 feet, b. m., 30 × 12 × 12.		63,600 feet, b. m., 20 × 12 × 12.		
			Per M ft., b. m.	Amount.	Per M ft., b. m.	Amount.	Total.
1	Abel H. Clark	Auburn, N. Y.	$18 00	$1,522 80	$18 00	$1,144 80	$2,667 60
2	E. H. French	Fulton, N. Y.	24 00	2,030 40	24 00	1,526 40	3,556 80
3	Post & Henderson*	Oswego, N. Y.					
4	Charles J. De Graw*	Fulton, N. Y.	17 40	1,472 04	17 40	1,106 64	2,578 68

	Name of bidders.	Residence.	CLASS II.—PINE TIMBER. 63,000 ft., b. m.				
			45,000 feet, b. m., 30 × 12 × 12.		18,000 feet, b. m., 20 × 12 × 12.		
			Per M ft., b. m.	Amount.	Per M ft., b. m.	Amount.	Total.
1	Abel H. Clark	Auburn, N. Y.					
2	E. H. French	Fulton, N. Y.	$32 00	$1,440 00	$32 00	$576 00	$2,016 00
3	Post & Henderson*	Oswego, N. Y.	30 00	1,350 00	30 00	540 00	1,890 00
4	Charles J. De Graw*	Fulton, N. Y.					

*Awarded.

Abstract of contracts for improvement of Little Sodus Harbor, New York, in force during the fiscal year ending June 30, 1872.

Name of contractors.	Residence.	Date of contract.	Subject of contract.	Remarks.
E. H. French	Fulton, N. Y.	June 16, 1871	Dredging	Contract closed Oct. 9, 1871.
E. H. French	Fulton, N. Y.	June 16, 1871	Materials and labor	Contract closed Sept. 30, 1871.
Post & Henderson	Oswego, N. Y.	Feb. 14, 1872	Pine timber	Contract closed June 11, 1872.
Chas. J. De Graw	Fulton, N. Y.	Feb. 19, 1872	Hemlock timber	Extended to Aug. 1, 1872.

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Abstract of contracts, with contract prices, for each class of materials and labor, for improvement of Little Sodus Harbor, New York, in force during the fiscal year ending June 30, 1872.

Name of contractors.	Residence.	Date of contract.	TIMBER.			IRON.		
			Pine timber.	Pine plank.	Hemlock timber.	Tree-nails.	Screw and washer bolts.	Drift-bolts.
			Per M. ft., b. m.	Per M. ft., b. m.	Per M. ft., b. m.	Per 100.	Per pound.	Per pound.
E. H. French	Fulton, N.Y.	June 16, 1871	$27 00	$27 00	$20 00	$5 00	$0 06	$0 04
E. H. French	Fulton, N.Y.	June 16, 1871	.....	.....	.....	.....	.....	.....
Post & Henderson	Oswego, N.Y.	Feb. 14, 1872	30 00	.....	.....	.....	.....	.....
Chas. J. De Graw	Fulton, N.Y.	Feb. 19, 1872	.....	.....	17 40	.....	.....	.....

Name of contractors.	Residence.	Date of contract.	STONE.		LABOR.				Dredging.
			Stone furnished.	Handling U. S. stone.	Moving cribs already framed.	Timber work.	Driving iron.	Driving tree-nails.	
			Per cord.	Per cord.	Each crib.	Per M. ft., b. m.	Per pound.	Per 100.	Per cubic yard.
E. H. French	Fulton, N.Y.	June 16, 1871	$6 00	$2 50	$20 00	$6 00	$0 01	$2 00	.....
E. H. French	Fulton, N.Y.	June 16, 1871	.....	.....	.....	.....	.....	.....	$0 17
Post & Henderson	Oswego, N.Y.	Feb. 14, 1872	.....	.....	.....	.....	.....	.....	.....
Chas. J. De Graw	Fulton, N.Y.	Feb. 19, 1872	.....	.....	.....	.....	.....	.....	.....

F 7.

OSWEGO HARBOR, NEW YORK.

Operations during the fiscal year have been carried on under contracts with Thomas Keeler, of Fulton, Oswego County, New York, for the repair of the old pier during the season of 1871, and for building a short breakwater in the angle near the light-house, and with R. Nelson Gere, of Syracuse, New York, for labor and stone for the new breakwater during the season of 1871. Operations upon the construction of two counter-forts for strengthening the old pier in the fall of 1871, and for the repair of the old pier and construction of the new breakwater during the season of 1872, have been carried on by hired labor; the timber and iron used during the season of 1871 were purchased in the open market; that used in 1872 was purchased by contract; the stone used in 1872 was purchased in the open market.

REPAIRS OF OLD PIER.

The repairs of the old pier consisted in removing all deck plank and sheathing that were rotten or broken, tearing up all broken superstructure and grillage bottoms, and replacing with new materials. The pier was left in good condition in the fall of 1871, but upon the opening of navigation in the spring of 1872 it was found that the ice had badly injured it, destroying three compartments of the superstructure; these

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were repaired by hired labor, and on June 30, 1872, the old pier was in fair condition.

ANGLE-CRIB NEAR LIGHT-HOUSE.

The heavy waves thrown against the light-house during severe gales caused so much vibration as to affect the machinery of the light; to remedy this evil a breakwater 100 feet long, 10 feet wide, and averaging 10 feet high, was constructed in the angle near the light-house; the result has been very beneficial.

COUNTER-FORTS FOR THE OLD PIER.

The weakness of the old pier caused fears that it would not stand the winter gales; two counter-forts, 33 by 20 feet, by 10 feet were therefore constructed, and after dredging for foundation, were sunk in rear of the pier and allowed to settle during the winter; in the spring of 1872 they were leveled up and the superstructure built to the proper height.

THE NEW BREAKWATER.

Operations upon the new breakwater were commenced July 5, suspended December 14, 1871, and renewed April 22, 1872.

The shore end was prepared by excavating the earth and rock until a smooth bed was obtained upon which the first grillage bottom was placed and securely anchored by drift-bolts driven into holes drilled in the rocks; from thence outward the most careful soundings were taken and the bottom made even or the cribs constructed to fill the spaces; cribs Nos. 10 and 14 were first constructed upside down so as to exactly fit the irregular formation of the rocky bottom, and then reversed and placed in position. Crib No. 17 was subjected to the most terrible gale of the season before it could be entirely filled with stone, and was shifted about 2 feet to the eastward; a wing was constructed and placed on the west side and securely bolted under water, a diver being employed for this purpose; to show the power of the wave during a storm, it is only necessary to state that the *effective* weight of this crib when moved was one hundred tons. Six hundred and forty linear feet of pier was constructed during the season of 1871, by Mr. R. Nelson Gere, of Syracuse, New York; eighteen cribs having been placed in position and sunk, and surmounted by a superstructure six feet high above ordinary low water.

In September, 1871, proposals were invited for timber, iron and tree-nails, for the season of 1872, and in October, 1871, they were awarded as follows:

Pine timber, to Leverich & Gardiner, of Port Hope, Ontario.

Hemlock timber, to Charles J. DeGraw, of Fulton, New York.

Tree-nails, to Jesse King, of Oswego, New York.

Iron, to James Caldwell, of Fulton, New York.

With the exception of Mr. C. J. DeGraw, these gentlemen have kept us fully supplied with materials; adverse circumstances, to which the latter claims to have been subjected, have so delayed him that it was found necessary to purchase in the open market in order to carry on the work satisfactorily; at his request the Department has extended the time of final delivery from June 20 to August 1, 1872.

By act of Congress approved April 26, 1872, Mr. R. Nelson Gere, of Syracuse, was released from further operations under his contract, and, by authority of the Department, work was resumed April 22, 1872, by hired labor.

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By June 30, 1872, we had succeeded in constructing and sinking eleven cribs, and in sinking one additional one, built in the fall of 1870; the angle-crib was pentagonal in shape in order to properly turn the angle, which was 120°; these cribs were of a height varying from 20 to 24 feet; the bottom of the lake is sand, but rock is found from 3 to 8 feet under it; the tendency of the cribs is to sink to the west and northwest, the severe gales from those directions washing out the sand; no superstructure has been constructed thus far this season, it being deemed advisable to await the complete settlement of the cribs.

There has been, therefore, constructed during the fiscal year, 1,059 linear feet of crib-work, upon which 640 linear feet of superstructure has been completed; the cribs are 35 feet square, except the one at the angle, and the depth varies from zero to 24 feet.

Although we have only gone a distance of 152 feet on the long arm, the effect of the breakwater is already very marked, the water being quite smooth inside when turbulent beyond.

The following amounts of materials have been used in the new breakwater during the fiscal year, viz:

307,826 feet, board measure, pine timber.
44,485 feet, board measure, pine plank.
1,129,443 feet, board measure, hemlock timber.
64,693 feet, board measure, hemlock plank.
622 feet, board measure, snubbing-posts.
4,265 tree-nails.
18,839 pounds screw and washer bolts.
112,468 pounds drift-bolts.
7,327 pounds boat-spike.
273 pounds boiler-iron.
4,265.6 cords of stone.

The operations carried on this season have been prosecuted with excellent results, a very large amount of work having been done.

During the present working season, it is proposed to continue operations upon the construction of the new breakwater, and to build during the year about 600 feet of it, in an average depth of 24 feet. The work will be done by contract provided advantageous bids are received, otherwise it will be carried on by hired labor and purchase of materials in open market.

Amount required to complete the work	$950,000 00
Amount available July 1, 1871	126,179 01
Amount expended during the year	82,851 06
Amount available July 1, 1872	143,327 95
Amount required for the fiscal year ending June 30, 1874	300,000 00

Fort Ontario is situated here. There is a light-house exhibiting a fixed white light of the third order, and a beacon on the outer end of the pier showing a fixed white light of the fourth order.

The amount of revenue collected at this port during the fiscal year was $1,006,172.60. The value of the imports was $7,018,264; 3,833 vessels with an aggregate tonnage of 604,590 tons entered, and 4,326 with an aggregate tonnage of 639,375 tons cleared during the year. It will be observed that in the amount of revenue collected, Oswego bears favorable comparison with other ports throughout the United States.

Abstracts of proposals and contracts are transmitted herewith.

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Abstract of proposals for furnishing materials for the new pier at Oswego, New York, opened by John M. Wilson, Major of engineers, October 26, 1871.

Number.	Names of bidders.	Residence.	CLASS I.—HEMLOCK. 1,065,120 feet timber, b. m. Per M ft. b. m.	Amount.	34,650 feet plank, b. m. Per M ft. b. m.	Amount.	Total.
*d*1	R. Nelson Gere	Geddes, N. Y					
*a*2	Charles J. De Graw	Fulton, N. Y	$18 00	$19,172 16	$18	$623 70	$19,795 86
3	Oliver Barrett	Oswego, N. Y	22 00	23,432 64	22	762 30	24,194 94
4	Post & Henderson	....do	19 00	20,237 28	14	485 10	20,722 34
*f*5	Thomas Keeler	Fulton, N. Y	22 00	23,432 64	22	762 30	24,194 94
*e*6	James Caldwell	....do	20 00	21,302 40	13	450 45	21,752 85
*b*7	James S. Leverich & James Gardiner	Port Hope, Ontario Co., N. Y					
8	S. B. Robinson	Sand Bank, Oswego Co., N. Y	18 95	20,184 02	13	450 45	20,634 47
*c*9	Jesse King	Oswego, N. Y					
10	O. J. Jennings†	Syracuse, N. Y	22 00	23,432 64	17	589 05	24,021 69

Number.	Names of bidders.	Residence.	CLASS II.—PINE. 251,160 feet 12×12 timber, b. m. Per M ft. b. m.	Amount.	26,250 feet 6×12 timber, b. m. Per M ft. b. m.	Amount.	52,500 feet plank, b. m. Per M ft. b. m.	Amount.	Total.
*d*1	R. Nelson Gere	Geddes, N. Y							
*a*2	Charles J. De Graw	Fulton, N. Y	$27 00	$6,871 32					
3	Oliver Barrett	Oswego, N. Y	30 00	7,534 80	$30	$787 50	$30	$1,575 00	$9,897 30
4	Post & Henderson	....do	30 00	7,534 80	20	525 00	20	1,050 00	9,109 80
*f*5	Thomas Keeler	Fulton, N. Y	27 00	6,781 32	27	708 75	27	1,417 50	8,907 57
*e*6	James Caldwell	....do	26 50	6,655 74	22	577 50	20	1,050 00	8,283 24
*b*7	James S. Leverich & James Gardiner.	Fort Hope, Ontario County, N. Y.	23 00	5,776 68	23	603 75	23	1,207 50	7,587 93
8	S. B. Robinson	Sand Bank, Oswego County, N. Y.							
*c*9	Jesse King	Oswego, N. Y							
10	O. J. Jennings†	Syracuse, N. Y	25 00	6,279 00	21	501 25	20	1,050 00	7,888 25

Number.	Names of bidders.	Residence.	CLASS III.—TREENAILS. 30″, 3,000; 24″, 1,000. Per 100.	Total.	CLASS IV.—IRON. 11,840 lbs. screw & washer bolts. Per lb.	Amount.	85,050 lbs. drift-bolts. Per lb.	Amount.	5,600 lbs. spikes. Per lb.	Amount.	Total.
					cts.		cts.		cts.		
*d*1	R. Nelson Gere	Geddes, N. Y			6½	$725 20	4½	$3,508 31	(*)		
*a*2	Charles J. De Graw	Fulton, N. Y	$8 50	$340	10	1,184 00	5	4,252 50	(*)		
3	Oliver Barrett	Oswego, N. Y									
4	Post & Henderson	....do									
*f*5	Thomas Keeler	Fulton, N. Y	10 00	400	7	828 80	7	5,953 50	7	$392	$7,174 30
*e*6	James Caldwell	....do	11 00	440	8	947 20	4½	3,508 31	9	504	4,959 51
*b*7	James S. Leverich & Jas. Gardiner.	Port Hope, Ontario County, N. Y.									
8	S. B. Robinson	Sand Bank, Oswego County, N. Y.	{30″ *a* 12 50 / 24″ *a* 10 00}	475							
*c*9	Jesse King	Oswego, N. Y	{30″ *a* 7 00 / 24″ *a* 6 50}	275							
10	O. J. Jennings†	Syracuse, N. Y	10 00	400	6	710 40	4	3,402 00	5½	329	4,441 40

(*a*) Lowest bidder for hemlock timber and plank—Class I.
(*b*) Lowest bidder for pine timber and plank—Class II.
(*c*) Lowest bidder for treenails—Class III.
(*d*) Lowest bidder for screw and washer bolts; James Caldwell on drift-bolts—Class IV.
(*e*) Ties, R. Nelson Gere, on drift-bolts—Class IV.
(*f*) Lowest bidder for spikes—Class IV.
* No bid for spikes in Class IV—iron.
† No certificate of responsibility of guarantors attached. Proposals state that it is intended as an entirety; name of George M. Case, one guarantor, believed to have not been signed by himself; other guarantor, G. D. Jennings, unknown.

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Abstract of contracts, with contract prices, for each class of materials and labor, for improvement of Oswego Harbor, New York, in force during the fiscal year ended June 30, 1872.

Names of contractors.	Residence.	Date of contract.	TIMBER.		IRON.				STONE.		TREENAILS.		LABOR.			
			Pine timber and plank.	Hemlock timber and plank.	Drift-bolts.	Screw and washer bolts.	Spikes.	Wrought washers.	Handling United States stone.	Furnishing stone.	30 inches long.	24 inches long.	Excavating.	Timber-work.	Driving iron.	Driving treenails.
		1871.	*Per M. ft. b. m.*	*Per M. ft. b. m.*	*Per pound.*	*Per pound.*	*Per pound.*	*Per pound.*	*Per cord.*	*Per cord.*	Per 100.	Per 100.	*Per cub. yd.*	*Per M. ft. b. m.*	*Per pound.*	Per 100.
Thomas Keeler	Fulton, N. Y	June 12	$29 00				$0 07	$0 09	$5 00					$5 50	$0 01	
R. Nelson Gere	Syracuse, N. Y	June 20							3 50	$5 75			$0 75	5 75	0 01½	$5 00
Leverich & Gardiner	Port Hope, Ontario Co., N. Y.	Nov. 6	23 00													
Jesse King	Oswego, N. Y	Nov. 13									$7 00	$6 50				
James Caldwell	Fulton, N. Y	Nov. 14			$0 04½	$0 08	09									
Charles J. De Graw	....do	Nov. 14		$18 00												

Abstract of contracts for improvement of Oswego Harbor, New York, in force during the fiscal year ended June 30, 1872.

Names of contractors.	Residence.	Date of contract.	Subject of contract.	Remarks.
Thomas Keeler	Fulton, N. Y	June 12, 1871	Materials and labor	Contract closed September 9, 1871.
R. Nelson Gere	Syracuse, N. Y	June 20, 1871	Stone and labor	Contract closed June 7, 1872; relieved by act of Congress.
Leverich & Gardiner	Port Hope, Ontario County, N. Y	Nov. 6, 1871	Pine timber and plank	Extended to August 1, 1872.
Jesse King	Oswego, N. Y	Nov. 13, 1871	Treenails	Contract closed April 16, 1872.
James Caldwell	Fulton, N. Y	Nov. 14, 1871	Iron	Contract closed March 11, 1872.
Charles J. De Graw	....do	Nov. 14, 1871	Hemlock timber and plank	Extended to August 1, 1872.

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F 8.

OGDENSBURGH HARBOR.

Proposals for the following work in this harbor were opened July 12, 1871, to wit:

For removing a bowlder in the Oswegatchie River; for dredging one section of the Saint Lawrence Channel between the mouth of the Oswegatchie and the Prescott ferry-dock; and for another section of the same channel east of the first one, and on its prolongation.

The first section covered an area within which the bottom was hard and consisted of an aggregation of cobble-stones, sand, gravel, &c., closely cemented together, and contained about 12,500 cubic yards in position to be removed. The bottom of the second section, except a small portion of it, consisted of ordinary clay, sand, &c., and contained 80,785 cubic yards in position to be removed.

The contracts for this work were awarded to the lowest bidders; Mr. Cornelius Daly, of Ogdensburgh, receiving the award of the bowlder and first section, and the second section being divided between him and Mr. W. S. Malcolm, of Oswego, New York, their bids being alike. Mr. Daly was given the upper portion, containing 40,499 cubic yards; and Mr. Malcolm the lower, containing 40,286 cubic yards.

Mr. Daly promptly commenced operations on July 13, 1871, and by the close of September had obtained a depth of 12 feet over the bowlder in the Oswegatchie, and completed work upon the first section in the Saint Lawrence Channel, making a clear channel 12 feet deep at extreme low water, 150 feet wide, and extending to the Prescott ferry. In dredging this channel, Mr. Daly removed 23,293 cubic yards measured in scows, for which he was paid $7,274. For obtaining the required depth over the bowlders, he received $125.

The price for the second section of the dredging was 15 cents per cubic yard in position. In the latter part of September Mr. Daly commenced work upon this section, and early in November he completed the first quarter of it, containing 10,124¾ cubic yards in position, to remove which he took out 29,008 cubic yards measured in scows. Operations were suspended November 20, on account of ice.

Work was resumed by Mr. Daly, April 18, 1872, and by the close of the fiscal year he had nearly completed his contract, having removed this season 21,368$\frac{12}{100}$ cubic yards measured in scows. While dredging in May, a ridge of hard-pan was struck, and by authority of the Secretary of War, Mr. Daly was not required to remove it, but confined his operations to that portion of the channel where the ordinary material was found. Mr. W. S. Malcolm, of Oswego, New York, although repeatedly called upon, has done no dredging whatever, and having utterly failed to fulfill his agreement, by direction of the Chief of Engineers his contract was annulled June 17, 1872.

During this season it is proposed to continue the dredging of the Saint Lawrence Channel, and to do a small amount of work in the Oswegatchie River.

Ogdensburgh is a port of entry in the collection-district of Oswegatchie; there is a fixed white light of the fourth order near the entrance to the harbor. Forts Ontario and Montgomery are each one hundred and twenty miles distant, the one to the southwest, the other to the east.

The amount of revenue collected during the fiscal year was $250,293.56; the value of the imports was $1,398,258; the value of the exports to Canada was $435,213; the number of vessels entering was 913 with an

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aggregate tonnage of 216,196 tons; the number clearing was 906, with an aggregate tonnage of 213,929 tons.

Amount of funds available July 1, 1871	$24,754 76
Amount expended during the year	12,003 78
Amount available July 1, 1872	22,750 98
But from this amount there is to be paid for work done during the year, but not yet due according to terms of contract, about	2,750 58
Leaving available for fiscal year ending June 30, 1873	20,000 00
Amount required for fiscal year ending June 30, 1874	6,000 00

Abstracts of proposals and contracts are transmitted herewith.

Abstract of proposals for dredging and removing bowlder in the harbor of Ogdensburgh, New York, opened by Major John M. Wilson, United States Engineers, July 12, 1871.

Number.	Name of bidder.	Residence.	Class I.—Removing bowlder, whole work.	Class II.—Dredging first section, hard bottom, whole section.	Class III.—Dredging second section, per cubic yard in position.	Remarks.
1	James Caldwell	Fulton, N. Y.	$300	$12,500	$0 35	One half of section 2 awarded.
2	William S. Malcolm	Oswego, N. Y.	.....	7,500	15	
3	Charles P. Morse & Co	....do	300	8,125	17	
4	Cornelius Daly	Ogdensburgh, N.Y.	125	7,274	15	Removing bowlder, section 1, and one half of section 2 awarded.

Abstract of contracts for improvement of Ogdensburgh Harbor, New York, in force during the fiscal year ending June 30, 1872.

Name of contractor.	Residence.	Date of contract.	Dredging. Removing a certain bowlder, whole work.	Dredging. Section of hard pan, whole work.	Dredging. Section of ordinary materials, per cubic yard in position.	Remarks.
William S. Malcolm	Oswego, N. Y.	July 19, 1871	.....	.....	$0 15	Annulled June 17, 1872.
Cornelius Daly	Ogdensburgh, N. Y.	July 24, 1871	$125	$7,274	0 15	

F 9.

OSWEGO HARBOR, NEW YORK.

UNITED STATES ENGINEER OFFICE,
Oswego, New York, January 5, 1872.

GENERAL: In compliance with the letter of the Chief of Engineers, dated December 21, 1871, inclosing a copy of a resolution of the House of Representatives of the United States, dated December 18, 1871, calling for a report as to "what extension of the public works on the east side of the mouth of the Oswego River, in the city of Oswego, New York, is desirable for the accommodation and protection of the

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increasing commerce of that port," I have the honor to report as follows:

The subject of increased harbor-room at Oswego, New York, was brought to the attention of Congress during the second session of the Forty-first Congress, and in accordance with a resolution of the House of Representatives, the Chief of Engineers called upon my predecessor, the late Major Bowen, for a report.

An able and exhaustive paper was submitted in March, 1870, and Major Bowen presented such an array of facts, showing the necessity of increased harbor-room, that repetition by me is deemed unnecessary.

In presenting his views, the following statement occurs:

> The river divides the city, and consequently each side has its special interest. Therefore I think the decision of a board of engineers upon the site of a new breakwater would give more general satisfaction than that of a single officer.

In accordance with this report, the Chief of Engineers, on the 26th of March, 1870, ordered a board of three engineer officers to convene at Oswego, for the purpose of reporting a plan for an outer harbor.

This board met on the 30th of March, and, after careful examination and due consideration of all the facts presented, decided that "the new work should be located north of the present west pier;" and, further, "that this will double the present capacity of the harbor, and suffice for at least thirty years."

On the strength of this report, approved by the Chief of Engineers and Secretary of War, two appropriations, amounting to $150,000, have been made. Work has been commenced, and during the present season 640 feet of the new breakwater has been completed. These facts are presented to show that the subject of the location of a new harbor at Oswego has already been carefully considered.

The season of the year will not admit of a survey being made of the lake east of the mouth of the Oswego River, and the map now on file shows only the soundings for a short distance beyond the limits of the Fort Ontario reservation. To that map, a tracing of which is on file in your office, I respectfully refer you, in connection with this report.

The city of Oswego, as mentioned before, is divided by the Oswego River. On the east side at present two railroads terminate—the Rome, Watertown and Ogdensburgh, and the New York and Oswego Midland. The former of these connects the city with Northern New England, and with the New York Central Road at Rome; and the latter, while also connecting with the New York Central, expects to open a direct road to New York City by August, 1872, and at the same time connects with coal-fields. New roads are contemplated between Oswego and Boston and Oswego and Portland. The former will probably connect with the Midland Road, and, therefore, have its terminus on the east side, but whether the latter will stop on that side, or cross the river three miles above, is, I understood, still an undetermined question.

As stated in the report of Major Bowen:

> The present harbor consists of a portion of the lake embraced by a jettee on each side of the mouth of the river, forming two small basins, and the Oswego River as far as the lower bridge, 3,000 feet from the light-house at the entrance of the harbor.
>
> On the east side of the basin is occupied by six lumber wharves projecting into it; ascending the river, next comes a small island, a coal depot, connected with the shore; then a very small basin running into the shore, just completed by private capital. From this basin up to the bridge the bank is occupied by elevators.

Since this was written the New York and Oswego Midland Railroad have erected extensive trestles and coal-pockets near the small basin.

From the foregoing it will be perceived that at present there is but

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little harbor room on the east side, and it certainly would be advantageous and add greatly to the prosperity of the city to increase it. The Midland Road terminating, and the Boston probably to terminate on that side, hope to draw to themselves a large portion of the trade of Canada and the lakes, daily becoming more profitable, and especially desire more harbor-room, whereby heavy freight can be transferred direct from vessel to cars, now entirely impossible. Commercially, therefore, an eastern as well as a western harbor would be advantageous.

But in accordance with the reports to which I have already referred, a large and commodious harbor is now under construction on the west side. The Delaware and Lackawanna Railroad, making a direct connection with the coal-regions of Pennsylvania, with New York City, and with the New York Central at Syracuse, already has its terminus on that side; the Lake Shore Railroad, now under construction, proceeding west a short distance from the lake, and crossing the Niagara River at Lewiston, will connect with the Great Western Railroad; it will also strike the Southern Central Railroad not many miles from Oswego, and thus open a new route to Philadelphia and the coal-fields of the Lehigh Valley; this road will terminate on the west side, and it is more than probable that eventually it will be absolutely necessary to construct a railroad-bridge across the Oswego River, and thus render the west-side harbor available to all.

In an engineering point of view, it would appear that a new harbor on the east side, with its entrance near the present light-house, and constructed after the manner of the one now in progress on the west side, would not be available for commerce until protected by a west breakwater from the action of the lake; the prevailing winds are from the west and northwest, particularly the latter, and the severity of some of the gales is terrible. An eastern harbor built now would feel the full effect of these; but when the western harbor is completed, it will afford ample protection for one on the opposite side.

The Fort Ontario reservation extends along the shore on the east side for about one-third of a mile, and, of course, all the ground above low-water mark there would be unavailable for commercial purposes. Certain parties, however, have, I am informed, received letters-patent from the State of New York for the land under water in front of the United States reservation.

I would respectfully call attention to the letter of Hon. D. C. Littlejohn, president of the New York and Oswego Midland Railroad, transmitted herewith. Mr. Littlejohn presents cogent reasons for the construction of an east breakwater; he requests that I should transmit with my report a sketch of the harbor, with the proposed breakwater upon the east side of the river. The map of the harbor is now on file in your office, but as yet the Engineer Department has proposed no breakwater on the east side, nor could such a plan be laid out until full and complete soundings have been made of the lake in that vicinity, and such work cannot be properly done without danger to life at this season of the year.

Being desirous that the citizens of Oswego should have the opportunity of full and free expression of thought on the subject, I addressed a communication to the president of the board of trade, forwarding a copy of the resolution, and requesting a statement in the form of a resolution as to their opinion on the desirableness of an east harbor, with such data as they might think proper to present. The board had the subject under consideration for two days, and the result is shown in the accompanying resolutions.

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It will be observed that the board of trade have asked for the speedy completion of the west harbor, as imperatively demanded by commerce, but state that it is felt that still greater harbor accommodation will be and is needed. They explain the general direction of the railroads, but have furnished no other data to show the necessity of the east side harbor, as requested. They close their resolutions by expressing their approbation at the movement for an east harbor, and asking for its inauguration and prompt construction, and at the same time desire no efforts relinquished for the speedy completion of the west harbor.

In conclusion, I have the honor to report that, while believing that an eastern harbor, in addition to the western one now being built, would be extremely desirable and advantageous for the accommodation and protection of the increasing commerce of the port of Oswego, New York, in consideration of the fact that a board of engineers has already decided that a new harbor should be at once constructed on the west side, and that in their opinion this would give sufficient harbor-room for thirty years, and the board of trade by resolution have requested that the west harbor be completed at the earliest practicable moment, although at the same time asking for an eastern one, and that as an engineering problem the construction of an eastern harbor would be more feasible and its occupancy more secure after the completion of the one now under construction, I am of the opinion that, for the present, all efforts should be concentrated to complete as rapidly as possible the new harbor on the west side, now being formed, and that when sufficient shelter shall have been obtained to form a good harbor there, steps should be taken for the formation of an eastern one, if it is found to be necessary.

I am, general, very respectfully, your obedient servant,

JOHN M. WILSON,
Major Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

OSWEGO, *January* 4, 1872.

At a meeting of the board of trade held this day, the following preamble and resolutions were passed unanimously, and were ordered to be transmitted to Major John M. Wilson, United States engineer, in charge of the Government work at this port:

Whereas Major John M. Wilson, Government engineer of the public works at this port, has referred to this board of trade the resolution recently introduced in Congress by Mr. Lansing, the Representative from this district, making inquiry as to the extension of the public works on the east side of the river in this city; and whereas we feel a deep interest in all improvements designed to enlarge our harbor, thus enabling us to retain the commerce which is now sought to be diverted because of inadequate facilities. Within a few years, the city of Oswego and her citizens have invested over $1,500,000 in the construction of new lines of railway. The New York and Oswego Midland Railroad, a direct and independent line from this city to New York, will be completed about the 1st of August next. The Watertown and Ogdensburgh Railroad connects us with Northern New England. The Lake Shore road is now being constructed, running hence to Niagara River, with promised connections to the eastward from this city. The Delaware, Western and Lackawanna Railroad leads from our city to New York, running through the great anthracite coal-regions of Pennsylvania; and we are soon to make connection with the Southern Central Railroad, giving us a new route to Philadelphia *via* the coal-fields of the Lehigh Valley. As the port of Oswego is expected to furnish these lines of railway much of their southern and eastward bound freight; therefore,

Resolved, That we view with great satisfaction the construction by the Government of the new outside harbor on the west side of the river. The demands of commerce imperatively require that this work shall be completed at the earliest practical moment. But even with the great increase in facilities that the present improvement will furnish, yet it is felt that still greater harbor accommodation will be and is needed; therefore,

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Resolved, That the movement for the continuation of the outer harbor to the east side of the river meets our cordial approbation and indorsement; and while we ask for the inauguration and prompt construction of this work, we do not wish the Government to relinquish its efforts for the speedy completion of the work now in progress on the west side, and we earnestly desire and request that the appropriations may continue and be sufficiently large as to enable the contractors to push the work to a speedy completion.

B. HAGAMAN, *President.*

E. A. HASTINGS, *Secretary.*

NEW YORK AND OSWEGO MIDLAND RAILROAD,
President's Office, Oswego, New York, December 30, 1871.

MY DEAR SIR: The United States Government is now engaged in constructing a breakwater upon the west side of the mouth of the Oswego River, for the purpose of increasing the capacity of the Oswego Harbor. This will be accomplished by its completion, and afford a protection to lake vessels, and proper facilities for the transfer of property from vessels to barges navigating our canals and inland water-lines.

There is, however, another great and important interest not accommodated by this improvement upon the west side of the river. I refer to the railroad interest.

There are three companies with roads finished and in process of construction, which are to exercise a large influence in moving the produce of the West to the Eastern States and our Atlantic cities, to wit, the New York and Oswego Midland Railroad, the Rome, Watertown and Ogdensburgh Railroad, and the Boston and Oswego Railroad, terminating, of necessity, upon the east side of the Oswego River. These roads must have access to the water of the Oswego Harbor, with large accommodations in the way of piers, docks, and warehouses, for the transfer of produce and property *in transitu* to the East, and merchandise, coal, iron, and other property destined for use and consumption in the Western States and the Canadas. You are aware that, in consequence of the high ground and limited harbor-room upon the east side of the river, no such accommodations can now be procured. You are also aware that it would require the abandonment of large expenditures already made, and a very large outlay in the future, with a much-increased distance, to enable these companies to avail themselves of the use of the improvement upon the west side of the Oswego.

In view of these facts, so briefly alluded to, as the president of the New York and Oswego Midland Railroad Company, and as a director in the Boston and Oswego Railroad Company, I take the liberty to suggest that a breakwater should be constructed upon the east side of the Oswego River, and that, if consistent with your views and duties as an officer of the Government, you will recommend the same to the proper authorities, with such other suggestions as your familiarity with our commerce and wants will enable you readily to do. May I also request that you will forward, with any report or papers which you may transmit, a sketch of the harbor, with the proposed breakwater upon the east side of the river, as proposed?

I beg further to add that, if desired by Congress, I have no doubt that one or more of these railroad companies would join the Government in paying the cost of the improvement.

Very respectfully, yours,

D. C. LITTLEJOHN,
President of New York and Oswego Midland Railroad Company.

Colonel JOHN M. WILSON,
Engineer U. S. A., United States Engineer Office, Oswego, New York.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., March 6, 1872.

SIR: I have to acknowledge the receipt, by reference to this office, of the letter of the chairman of the Committee on Commerce of the Senate of the United States, of the 15th February, inclosing copy of Senate bill No. 604, "to allow the Lake Ontario Shore Railroad Company to lay their track upon the west pier at Oswego, New York," and requesting information, &c., and beg leave, in reply, to invite attention to the following extract from the indorsement of this office of February 5, on the application to the War Department of the president of the Lake Ontario Shore Railroad Company for the privilege proposed to be granted by the Senate bill:

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The construction of the new breakwater will convert the west pier of Oswego Harbor into valuable wharf-property, the proceeds of the sale of which might be applied to the still further improvement of the harbor.

The pier should be sold at public sale (reserving a right of way to the light-house) at a suitable time, authority for the sale having been previously obtained from Congress.

It may be added that the occupation of the pier by the railroad company will virtually enable that company to control its sale by claiming, and no doubt obtaining, from the State of New York the sole property-right to the bottom of the harbor and lake on either side of the pier, and erecting structures upon the land thus acquired contiguous to the pier.

The harbor of Oswego is crowded, and additional space is much needed. I am not, therefore, disposed to recommend any course which would prevent the earliest practicable use of the pier for wharfage, nor at the same time to recommend such disposition of it as would deprive the Government of valuable property acquired by large expenditures.

Perhaps the wants of the Lake Ontario Shore Railroad Company, the interests of the Government and of the city of Oswego, might be harmonized by obtaining from Congress authority for the public sale, by the Secretary of War, to the highest responsible bidder, of so much of the west pier of Oswego Harbor, and at such times as he may deem compatible with the public interests; and, until such sale is made, to authorize the Secretary of War to lease the same to the Lake Ontario Shore Railroad Company, or other parties, for such periods, not exceeding three years, and upon such terms and conditions as he may think the public interests may require, reserving to the United States the right to annul the lease whenever in the opinion of the Secretary of War the exigencies of the public service may render it necessary.

A project of a bill embodying these views is herewith submitted.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

A BILL to authorize the Secretary of War to sell the west pier at Oswego Harbor, New York, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to sell at public sale, to the highest responsible bidder, so much of the west pier of Oswego Harbor, New York, and at such times, as he may deem compatible with the public interests: *Provided*, That, until such sale is effected, the Secretary of War is authorized to lease the said pier to the Lake Ontario Shore Railroad Company, or other parties, for such periods, not exceeding three years, and upon such terms and conditions as in his judgment the public interests may require, reserving to the United States the right to annul the lease whenever, in the opinion of the Secretary of War, it may be demanded by the exigencies of the public service.

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APPENDIX G.

ANNUAL REPORT OF LIEUTENANT-COLONEL JOHN NEWTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDED JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Army Building, New York, September 5, 1872.

GENERAL: I have the honor to submit herewith my annual report upon the following works under my charge for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

G 1.

IMPROVEMENT OF PLATTSBURGH HARBOR.

During the year the superstructure of the extension of 94 feet in length, commenced the previous season, has been completed.

The crib-work of the extension of 150 feet in length, commenced in June, 1871, was completed and sunk in position in the month of July, 1871, and work on the superstructure was commenced in the month of September, 1871, but, owing to unfavorable winds, the work was suspended, and at the close of the year remains unfinished.

Under appropriation for this harbor of June 10, 1872, it is proposed to continue the extension in a northeasterly direction for 75 feet.

To complete the extension of the breakwater about 80 feet farther, which is all that is needed, and for the repairs of the southern end of the breakwater, an additional appropriation of $15,000 for the fiscal year ending June 30, 1874, is asked.

Cash Statement.

July 1, 1871.—Amount available		$18,830 70
January 30, 1872.—Amount unexpended balances in Treasury	$1,073 68	
January 19, 1872.—Amount appropriated by act of June 10, 1872	10,000 00	
		11,073 68
		29,904 38
Amount expended		13,082 21
July 1, 1872.—Amount available		16,822 17
In Treasury	$11,073 68	
In hands of agent	5,748 49	
		16,822 17
Amount desired for fiscal year ending June 30, 1874		$15,000 00

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

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G 2.

IMPROVEMENT OF BURLINGTON HARBOR.

During the year the superstructure of the extension of 171 feet, commenced the previous season, has been completed.

The crib-work of the extension of 217 feet in length in a southerly direction, commenced in June, 1871, has been completed, the cribs having been sunk in position, one in September and the other in October, and work on the superstructure was commenced in February, 1872, and finished in June, 1872.

Under appropriation for this harbor of June 10, 1872, it is proposed to continue the extension in a southerly direction for 180 feet.

The extension of this breakwater from both extremities is necessary in order to give shelter at the wharves of the city, which have been much extended.

Amount asked for the fiscal year ending June 30, 1874, $30,000, which, in my opinion, is very moderate, considering the necessities of the case.

The work is done by contract.

Cash statement.

July 1, 1871.—Amount available		$36,452 77
January 30, 1872.—Amount of unexpended balance in Treasury	$9,977 08	
June 19, 1872.—Amount appropriated by act of Congress of June 10, 1872	30,000 00	
		39,977 08
		76,429 85
Expended June 30, 1872		33,826 97
July 1, 1872.—Amount available		42,602 88
In Treasury	39,977 08	
In hands of agent	2,625 80	
		42,602 88
Amount desired for fiscal year ending June 30, 1874		$30,000 00

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

G 3.

THE IMPROVEMENT OF OTTER CREEK, VERMONT, FROM VERGENNES TO ITS OUTLET ON LAKE CHAMPLAIN.

An appropriation of $10,000 (approved June 10, 1872) has been made for this work.

No disbursements were made during the fiscal year ended June 30, 1872.

The amount appropriated will be devoted to dredging upon the shoals in this creek, and a contract for the same, after public advertisement, has been awarded.

The estimate for the improvement is $58,146, as by my report of February 15, 1872, and I think the balance, $48,146, should be appropriated in one sum.

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ARMY BUILDING, NEW YORK,
February 15, 1872.

GENERAL: I have respectfully to transmit herewith two sheets of tracings of survey of Otter Creek, Vermont, from Vergennes to its outlet; also tracing of general map of the country drained by the creek and its tributaries, and copies of Mr. D. White's report upon the improvement of the navigation from Vergennes to Lake Champlain, and of paper furnished by his honor the mayor of Vergennes, upon the amount of business likely to be benefited by the removal of existing obstructions to navigation.

The survey of this creek was assigned to Mr. D. White, civil engineer, with written and verbal instructions from my office concerning the essential points to be observed.

The survey and report of Mr. White have been carefully made, and contain all the matter essential to a comprehension of the problem, and the means of its solution.

The results of the examination show that the navigation of the creek can be sufficiently improved, and maintained in good state.

I am not satisfied that the simple dredging of the basin at Vergennes would make a permanent improvement, and have consequently indicated lines of crib or pile work to be constructed with the object of narrowing the channel and of forming a place of deposit for the sand, which may be held suspended in the agitated waters of the falls. The cost of works of improvement will not exceed that of dredging, so that either course, as a thorough examination should dictate, might be adopted. Fascine groins are indicated at various places along the banks; the cost of this mode of construction is little, and its application in this locality, wherever it may be necessary to regulate the cross-sections, or prevent erosion, would be very convenient.

Looking to a future complete improvement of the creek, several points of interest are noted, viz: Shore protection at Sharkey Bend; constructing a more gradual curve at Crittenden's Bend; changing the outlet of Dead Creek; and filling the re-entering at Fort Cassin. All of these, however, are matters which may be delayed for a term of years, and, perhaps, may never be needed.

I submit three estimates—that of Mr. White, for dredging alone, $51,000; a second, that of a complete project, $106,842; and a third, combining dredging, fascine-work, and diking, amounting to $58,146. The last would be sufficient for a great improvement of navigation, which would, probably, likewise be permanent.

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army.

FORT MONTGOMERY, ROUSE'S POINT, NEW YORK,
January 23, 1872.

GENERAL: I have the honor to submit the following report in relation to the improvement of Otter Creek. Otter Creek is the largest stream in the State of Vermont. As may be seen by map A, of the maps A and B, herewith transmitted, it rises at a place called Mount Tabor, in the towns of Peru and Dorset, Vermont, near the head of the Battenkill River. Its course from its origin to the town of Rutland is nearly north, and from thence it changes to northwesterly, through Addison County to Lake Champlain, at a point called Fort Cassin; its entire length being about ninety miles. Its

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tributaries are as follows: From the southwest it receives in the town of Ferrisburgh, at a point about five miles below Vergennes, a large, sluggish stream called "Dead Creek," which originates in the town of Bridport; Lemonfair River debouches in at Weybridge, originating at Orwell and Shoreham. In Rutland, Tinmouth River empties in, and at Mount Tabor a small stream called Mill River; while from the east it receives the waters of New Haven River, in the town of New Haven, Vermont. There also empties in, Middlebury River, at Middlebury; Leicester River, at Leicester; Furnace River, at Pittsford; with Cold River and Mill Creek in Clarendon—all of which are said to be considerable mill-streams, the whole making a water-shed of probably not less than 850 square miles.

The creek is subject to sudden rises, and during my operations in the month of August it rose 6 feet in about thirty-six hours. Above Middlebury and between Middlebury and Pittsford, Otter Creek is said to be a still, deep stream. At Middlebury, Weybridge, and Vergennes, are fine mill-sites—the latter having from the mill-pond to the basin below a fall of about 36½ feet. From this point to Lake Champlain, a distance of eight miles, the creek has been made the subject of a careful survey.

As may be seen by reference to map B, herewith transmitted, the creek has a mean width of about 185 feet, between banks, and an average depth of about 10½ feet; its maximum rise above the plane of low water is about 7 feet, with a mean velocity of 0.2 at low, and about 6.2 miles per hour at high water. The latter rate of current, however, probably obtains only during the summer and autumn freshets when Lake Champlain (into which it empties) is at a low stage, which gives the volume greater declivity.

From the nature of the present banks, the underlying timber, and general appearance of the adjacent lands, it is more than probable that this section of the stream had a much greater width at no very distant date, but owing doubtless to the natural result of cultivating the water-shed, it has been reduced to its present limits.

The banks of the creek, or more properly its "intervals," vary in level from one to ten feet above the plane of low water, the lower portions of which are covered with a dense growth of marine plants, and the higher, with few exceptions, with willow, alder, soft-maple, and oak timber.

The depth of water required for purposes of navigation for steamers and sail-craft plying between ports on Lake Champlain and Vergennes, being 8 feet, as may be seen by the soundings shown in the map B, the navigation has become greatly impeded by the filling up of the basin at Vergennes, and the formation of shoals and bars at Bull Brook, Smith's Bend, Brick-Yard, Dead Creek, Crittenden Bend, and Fort Cassin, points farther down.

As to the cause and nature of these deposits: Many years since, two loaded cribs, each about 25 by 18 feet, were sunk in the basin at respectively 300 and 500 feet below the foot of the falls, for the purpose of booming logs, and that probably about the same time were driven a clump of some thirty piles, at a point nearly opposite the upper coal-yard, for the center-pier of a railroad-bridge. These stopping and holding the *débris* coming down from the saw-mills located on the tributaries above, which, until a very recent period, it was the custom to waste into the stream, formed a nucleus for the collection of silt and the propagation of the shoals and bars met with in the basin proper; as also the formation of these at the other points mentioned above, except that at Crittenden Bend and Fort Cassin, which are due to nearly the same cause, viz, natural obstructions, such as stone existing in the soil, and the toppling over into the stream and lodgment at its bottom of large maple and oak trees, aided by the local neutrality of the current at those points, the latter resulting from a deflection of the current by irregular indentations in the banks, the shoal at Crittenden Bend not being a formation of alluvion, but a prominent projection of the original bank, which the corrosive action of the creek has been too feeble to remove.

The contraction of the channel at Fort Cassin is due to the intrusion of the margin of an extensive alluvial deposit formed in the bay at the left of the fort, and reaching out nearly, if not quite, to the middle of Lake Champlain. This flat is the result of a gradual accumulation for perhaps centuries, caused by the flanking and sudden deflection to the south and southwest of the current by "Fort Cassin Point," projecting into its path, which, meeting the opposing currents of Lake Champlain on reaching the bay, releases its burden of silt, brought down from its extensive water-shed. This alluvial deposit is very evenly distributed, as shown by the soundings on the accompanying map, it varying but little in depth for many rods, until at the very verge of the flat; the water then deepens rapidly to fifty feet, and probably more. Fifty feet being the maximum length of the sounding-line used, I was unable to carry on investigations beyond this limit.

In looking at the cause of these obstructions, and providing a remedy, it is also necessary to regard the business interests established which may be affected by our action, and to inquire whether they are of such a nature and extent as to require the full capacity of the stream, and hence the elimination of all the intruding matter. As will be seen by a glance at the map, both sides of the Vergennes Basin are occupied for purposes of commerce, the eastern bank for the reception and shipments of lumber, coal,

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wood, &c., and the western, together with the crest of the falls, by a large number of manufacturing establishments, all of which receiving and shipping large quantities of freight, in the way of raw material and manufactured wares, through this natural commercial highway, as will be shown by the statistical report to be furnished by his honor G. W. Grandey, mayor of the city of Vergennes. Deeming it necessary, I would respectfully recommend the following plans of improvement, which I have arranged in the order of their relative importance:

I. Remove the loaded cribs and old piles and dredge out the basin to a depth of 8 feet from the "steamboat landing" and as far up as the outlet of "Pot-ash Brook," thence along the west shore a channel of the same depth, 100 feet wide, as far up as the Horse-nail Company's wharf at the foot of the falls, and by thus dividing the work in the basin, the pressing need of a water communication for the manufacturing interests along the banks would be soonest relieved. This will require the removal of—

48,200 cubic yards of silt and saw-mill *débris*, at 50 cents per cubic yard	$24,100
To which must be added, in order to complete the work in the basin and render its whole area available, the removal at some future time of 19,200 cubic yards of the same material, at 50 cents	9,600
Removing two loaded cribs, at $200 each	400
Removing thirty piles, at $5 each	150
Contingencies	3,450
Total	37,700

II. *Bull Brook.*—At this point the shoals seem to be composed of stone, clay, and sand, the contents of which amount to—

5,700 cubic yards, at 55 cents	$3,135
Contingencies	365
Total	3,500

III. *Smith's Bend.*—The quantity of material to be removed amounts to—

2,900 cubic yards compost, clay, and sand, at 50 cents	$1,450
Contingencies	150
Total	1,600

IV. *Brick-yard.*—Nature of shoals, clay and sand.

Quantity, 4,200 cubic yards, at 50 cents	$2,100
Contingencies	200
Total	2,300

V. *Dead Creek.*—

1,900 cubic yards of sand and loam, at 50 cents	$950
Contingencies	150
Total	1,100

VI. *Crittenden Bend.*—Nature of bar, a species of blue clay, apparently free from stone.

Amount to be removed, 1,100 cubic yards, at 60 cents	$660
Contingencies	140
Total	800

VII. *Fort Cassin.*—Ordinary alluvion.

Amount to be removed, 8,000 cubic yards, at 40 cents	$3,200
Contingencies	300
Total	3,500

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VIII. For the removal of 50 trees from the margin of the stream, to prevent their falling in and impeding navigation, at $10, $500.

RECAPITULATION.

Vergennes Basin	$37,700
Bull Brook	3,500
Smith's Bend	1,600
Brick yard	2,300
Dead Creek	1,100
Crittenden Bend	800
Fort Cassin	3,500
Removal of 50 trees	500
Total	51,000

However, instead of dredging away the intruding margin of the above-mentioned shoal at Fort Cassin, I think the desired improvement could be made and maintained at less expense by the construction and sinking of about 500 linear feet of crib-work of such height as to bring the top even with the plane of low water, as shown in the position of the dotted line at C.

By this arrangement, I think, a sufficient proportion of the volume would be retained to effect the desired end without causing a radical change in the place of the present general deposit, as the upper portion of the volume would, during its high stages, pursue its natural course by flowing over the crib-work.

Crib-work suited to the above purpose would require to be of the following dimensions, viz: Average height, 4 feet, and width, 8 feet, and would cost $4 per linear foot—$2,000 for the 500 feet—which would reduce the ultimate expense to the amount of $1,200.

In regard to the maintenance of the other improvements when made, I may say that, in view of the effective corrosive action of the current under the present circumstances, as may be seen by the irregular depths to which it has carried its channel until it has reached soil of a more permanent character, such as clay, stone, and gravel, the very brief period during which the current maintains its level above that of its banks at its higher stages, the well-protected state of the banks by marine plants and trees of various species, and the discontinuance of the practice of wasting saw-mill litter and *débris* into the stream, I think that additional works looking to that end, except the removal of the trees above referred to, growing immediately upon its shores, are unnecessary.

Very respectfully, your most obedient servant,

D. WHITE,
Superintendent and Engineer.

Brevet Major-General JOHN NEWTON,
United States Engineers.

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Comparative estimates.

Locality of improvement.	Designation of work.	First project.		Second or completed project.		Second project modified by omission of works of probable necessity only, or of such as may be postponed for a term of years.	
Basin at Vergennes	Dredging from falls at Vergennes to steamboat landing	*$37,095		†$15,351		$15,351	
	Removing cribs, $440; removing piles, $165	605					
	Shore protection			1,760			
	Diking			14,520		14,520	
	Fascine-work			4,858		3,000	
			$37,700		$36,489		$32,871
Bull Brook	Dredging	3,500		920		920	
	Fascine-work			2,270		2,270	
			3,500		3,190		3,190
Sharkey Bend	Shore protection			5,720			
					5,720		
Smith's Bend	Dredging	1,600		183		183	
	Fascine-work			3,168		3,168	
			1,600		3,351		3,351
Brick-yard	Dredging	2,300		2,444		2,444	
	Fascine-work			2,165		1,800	
			2,300		4,609		4,244
Dead Creek	Dredging	1,100		1,430		1,100	
	Diking			1,815			
	Fascine-work			1,742			
	Dredging new outlet			6,111			
			1,100		11,098		1,100
Gage's Bend	Shore protection			1,200		1,200	
					1,200		1,200
Crittenden Bend	Dredging	800				800	
	Shortening bend			11,733			
	Diking			13,310			
			800		25,043		800
Fort Cassin	Dredging	3,500					
	Fascine-work			4,752			
	Crib-work			10,890		10,890	
			3,500		15,642		10,890
Along the banks	Removing trees	500		500		500	
			500		500		500
Total			51,000		106,842		58,146

* To eight feet in depth. † To ten feet in depth.

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The following schedule contains an estimate of the imports and exports to and from Vergennes, Addison County, Vermont, through Otter Creek, for the year 1871:

Tons.	Articles transported.	Value.
2,500	Pine lumber—1,700,000 feet; value, $62,000	$62,000 00
100	Sash, doors, and moldings—100 tons; value, $3,000	3,000 00
350	Plaster—350 tons; value, $2,100	2,100 00
100	Curtain-rolls—100 tons; value, $7,500	7,500 00
380	Timber—190 cords; value, $2,000	2,000 00
2,000	Wood—1,000 cords; value, $4,000	4,000 00
525	Merchandise—525 tons; value, $262,500	262,500 00
100	Steel, iron, nails, &c.—100 tons; value, $8,000	8,000 00
70	Molding-sand—70 tons; value, $300	300 00
95	Excelsior—95 tons; value, $2,375	2,375 00
50	Spokes, hubs, and fellies—50 tons; value, $6,000	6,000 00
1,100	Kaolin—1,100 tons; value, $18,000	18,000 00
400	Brick—200,000; value, $1,500	1,500 00
750	Stone—500 perch; value, $1,000	1,000 00
300	Sand and gravel—300 tons; value, $600	600 00
50	Salt—50 tons; value, $1,000	1,000 00
1,800	Coal—1,800 tons; value, $12,600	12,600 00
400	Staves—400 tons; value, $8,000	8,000 00
3,300	The steamer, Curlew, of 100 tons, 165 round trips, estimated to carry 10 tons each way, making 3,300 tons; value, $330,000.	330,000 00
	And carrying 15 passengers each way, making 4,950 passengers, each $1.25; value, $6,187 50.	6,187 50
14,370	Total	738,662 50

CITY OF VERGENNES, VERMONT,
January 24, 1872.

I, George W. Grandey, mayor of the city of Vergennes, hereby certify that I have carefully examined the statements of the business men of Vergennes, from which the foregoing schedule has been compiled, and being well acquainted with them and their business, I have full confidence in the correctness of their several statements, and can safely vouch that, in my judgment, they are within the bounds of truth.

I can further say that no inconsiderable amount of transportation, both to and from Vergennes, not enumerated in this schedule, is done through said river every season by business men, manufacturers, and merchants in adjacent towns and towns in Addison County, and also that a very large amount of transportation to and from Vergennes of goods, wares, and merchandise, and other property of great weight and bulk, has been done by railroad for many years past, which would have been done through said creek if its channel and its principal basin had been open and unobstructed.

In testimony whereof I have hereunto set my official hand and the seal of said city, at Vergennes, Addison County, Vermont, this 24th day of January, A. D. 1872.

[SEAL.]

GEO. W. GRANDEY,
Mayor of the City of Vergennes, Vermont.

APPENDIX H.

ANNUAL REPORT OF COLONEL J. N. MACOMB, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

ROCK ISLAND, ILLINOIS,
September 23, 1872.

GENERAL: In laying before you the annual reports of the assistants in local charge of the several works under my general supervision, I have the honor to offer the following summary:

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H 1.

ROCK ISLAND BRIDGE.

The superstructure of this great bridge remained in the local charge of Captain W. H. H. Benyaurd, Corps of Engineers, United States Army, until its completion. The report of Captain Benyaurd (H 9) and accompanying letter (H 10) to him from Mr. C. Shaler Smith, president Baltimore Bridge Company, are herewith submitted, and I beg leave to refer to the same for interesting facts touching the details of construction of the bridge, which was satisfactorily tested on the 8th of May, 1872, as reported to you in my letter of the 21st of that month.

The substructure of the bridge remained in charge of Captain Amos Stickney, Corps of Engineers, United States Army, until its completion. The wagon-road approaches and the deepening of the channel between the draw-pier and the island, and some other accessories, were also in his charge, and will be reported upon by him as soon as possible after their completion. His report for fiscal year ending 30th June, 1872, is herewith submitted, marked H 11.

Of the funds appropriated for the bridge, I had—

On hand 1st July, 1871	$158,778 28
Received during the fiscal year ending 30th June, 1872	453,000 00
	611,778 28
Expended during fiscal year	586,140 39
In my hands 1st July, 1872	25,637 89
Balance in Treasury 1st July, 1872	117,309 57
Amount available on 1st July, 1872, for completing accessories of bridge and meeting current expenses of keeping and repairs	142,947 46
Of which there will be required in current fiscal year about	42,947 46
Leaving an amount now in Treasury	100,000 00

The contractors for the superstructure of this work are to be commended for producing such a perfect result, to effect which they spared themselves no expense, and are understood to be losers by their contract.

H 2.

PRESERVATION OF THE FALLS OF SAINT ANTHONY

The survey made in the early part of the fiscal year showed the necessity of much more extensive works at this place to effect the end in view, than had at first been contemplated. The results of this survey and the new projects based thereon were submitted to you in my report dated 5th April, 1872, to which I would now refer for a history of the work during the past year. (Appendix H 12.)

Of the funds for this work, I had on hand July 1, 1871	$8,574 17
Received during the fiscal year ending 30th June, 1872	30,000 00
	38,574 17
Expended during the fiscal year	36,153 64
	2,420 53
Appropriated 10th of June, 1872	50,000 00
Available 1st July, 1872	52,420 53

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Some of which has been applied to contingencies in keeping the works in repair, and the greater part of it will be applied to extending the works.

The new project has been approved by the board of engineers called to consider the subject, but can only be begun on receiving the amount estimated in the report above referred to, making the amount required to be appropriated for the preservation of the Falls of Saint Anthony and the navigation of the Mississippi River, above the same, the sum of $200,000.

H 3.

IMPROVEMENT OF THE MINNESOTA RIVER.

From the 1st September, 1871, to the 25th of January, 1872, this work was prosecuted by the contractor, Mr. S. A. Hooper. An account of the operations is given in the report of the inspector, Captain Edwin Bell, marked H 15, by which it will be seen that the channel was cleared of bowlders from the mouth of Yellow Medicine River down to Fort Ridgely, a distance of seventy miles; the work being chiefly confined to removal of bowlders. It is hoped that the contract arising under our new advertisement may result in the removal of snags which we were obliged to pass by for want of sufficient funds last year.

Found on hand 1st July, 1871	$96 44
Received during the fiscal year ending 30th June, 1872	10,137 47
	10,233 91
Expended during the fiscal year	10,016 51
	217 40
In Treasury from appropriation of June 10, 1872	10,000 00
Total amount available 1st July, 1872	10,217 40

Which will be applied to continuing the improvement of the Minnesota River towards Mankato. A survey is now in progress which will show the capabilities of this river between its head and the mouth of Yellow Medicine, also its relation to the Red River of the North. The amount required for continuing the improvement of the Minnesota River for the next fiscal year is $20,000.

H 4.

IMPROVING UPPER MISSISSIPPI RIVER.

This work was intrusted by me to the immediate charge of Captain J. Throckmorton, whose experience in the navigation of this river began at an early day, and has extended over a period of some forty years. His report (marked H 16) shows the details of the operations from the commencement of his supervision to the end of the last fiscal year.

Available for this work 1st July, 1871	$45,064 14
Expended during fiscal year ending 30th June, 1872	44,019 46
Remaining July 1st, 1872	1,044 68
Appropriated June 10, 1872, under head of "snag-boats and dredges on Mississippi River"	42,000 00
	43,044 68

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Which will be applied in continuing operations during the current fiscal year, and there will be required for this work during the fiscal year ending June 30, 1874, an appropriation for a steamer of light draught, to replace the steamer Caffrey, $30,000; and for current expenses of two steamers through the year, $42,000; total, $72,000.

H 5.

IMPROVEMENT OF ILLINOIS RIVER.

The work upon the Illinois River improvement is fully set forth in the accompanying report marked H 17, from R. E. McMath, civil engineer, assistant in local charge. During the last fiscal year operations on this river were confined chiefly to carrying out the project referred to in my annual reports of 1870 and 1871, viz, to make an open channel navigation with a minimum depth of 4 feet. At the beginning of the fiscal year work was in progress under two contracts, one with F. D. Van Wagenen, nearly completed, and the second with James T. Hayden, under appropriation of $100,000 made in session of 1869–'70, of which $63,729.90 was then unexpended. Under the contract with James T. Hayden work has been in progress throughout the year, and some delays have been experienced, owing to the extreme low water, but during the present season work has advanced in the most favorable manner, so far as the means provided would allow.

The results of the year's operations show:

Expended for dredging	$42,748 74
Expended for wrecking	2,250 00
Expended in building dams	7,746 40
Total during the year	52,745 14

The total amount expended during the progress of the improvement, exclusive of engineering expenses, is $138,758.81.

No appropriation having been made since 1870, the available funds have already been expended, and the improvement awaits the further action of Congress. The assistant in local charge of the work reports the filling up of the improved channel at Kickapoo Creek by a flood, and says that this may be expected at any time at certain other points, and that the only remedy, in case of its occurrence, is in annual appropriations for maintenance and prompt restoration. The annual cost of such maintenance he estimates at $12,000. An estimate for the completion of a channel, giving 4 feet draught, from Henry to the mouth of the river, has been prepared, amounting to $350,000. Of this amount $150,000 could be profitably expended during the next fiscal year.

On hand July 1, 1871	$25,729 90
In the Treasury July 1, 1871	38,000 00
Total available	63,729 90
No new appropriation having been made—	
Expended during the fiscal year ending June 30, 1872	51,181 37
Leaving	12,548 53

Which will be applied to settling with contractors, and for contingent expenses of the work, and any further operations will be entirely dependent upon future appropriations. There is asked for the fiscal year ending 30th June, 1874, $150,000.

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H 6.

IMPROVING DES MOINES RAPIDS, MISSISSIPPI RIVER.

The operations upon this work are fully set forth in the report (marked H 18) of Captain A. H. Burnham, Corps of Engineers, United States Army, herewith appended, and to which I beg leave to refer. As explained in my last annual report—

There was available for this work on July 1, 1871, (being difference between amount in Treasury, $400,000, and amount due from United States, $110,944.06)	$289,055 94
Of which there was applied for disbursements, during fiscal year ending 30th June, 1872	288,843 41
Leaving on hand July 1, 1872	212 53
To which must be added appropriation of 10th June, 1872	400,000 00
And we have amount available at the commencement of current fiscal year.	400,212 53

All of which will be applied to pushing forward this important work during the early part of current fiscal year.

For reasons stated by Captain Burnham, the assistant in charge, I would respectfully urge that a larger appropriation than those made of late should be granted, and I therefore ask for $1,000,000 for continuing the work.

H 7.

IMPROVING ROCK ISLAND RAPIDS.

The report (marked H 21) of Major E. F. Hoffmann, civil engineer, assistant in local charge, gives a history of the work for the past year, by which it will be seen that much more work than usual has been done during the year, owing, in great measure, to the zeal and activity displayed by the present contractor, as well as to the favorable conditions under which he has been working.

This important improvement has now been in progress for five years, and the work has been executed in detached parts, at the various places of greatest obstruction, not always regarding the order in which the obstructions succeeded each other in the river. For aiding in the study of the manner in which the improved portions of the channel can best be rendered available to the navigators of the river, additional surveys have been made, as shown in the report of the assistant in local charge. These surveys demonstrate the necessity of removing certain obstructions, the extent of which was not previously fully developed. For executing this work an estimate is presented, which, if granted, will, it is expected, lead to such final improvement as will allow the passage over the rapids, at all stages of water, of the largest steamers used upon the Upper Mississippi River.

Cash available July 1, 1871, as follows:

Reported in my hands, as by last annual report and tabular statement...	$18,010 44
Amount then supposed by me to be available in the Treasury.	253,000 00
Add to this last amount, in accordance with information since received from the Treasury	700 28
And we have the true amount available on July 1, 1871	271,710 72
Expended during the fiscal year ending June 30, 1872	191,513 29
Remainder	80,197 43

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Appropriated June 10, 1872	$50,000 00
Available on July 1, 1872, (being difference between amount as by tabular statement accompanying this report, $130,700.28, and amount due from United States, $502.85)	130,197 43

A large portion of which is due to contractors, as retained percentage; the remainder will be applied to the completion of the work at Saint Louis Chain, and to the improvement of the channel at Winnebago Island, the cost of which will, without a doubt, be covered by the amount now available. For the entire completion of the rapids improvement, there remain about 9,000 cubic yards of rock to be removed at lower chain, foot of Moline Chain, and head of Duck Creek Chain; the former point being of special importance, as taken in connection with the proposed landing at Rock Island Arsenal.

For the completion of the work, as set forth in the report of Major E. F. Hoffmann, the able assistant in charge, there will be required the sum of $108,000; the granting of which I would most earnestly recommend to make this improvement the most complete and satisfactory of any as yet made on the Mississippi River.

REPAIR, PRESERVATION, EXTENSION, AND COMPLETION OF CERTAIN PUBLIC WORKS.

Of the above-named appropriation, approved on the 25th July, 1868, I had—

On the 1st of July, 1871, the sum of	$18,376 90
Of which I have expended, during the fiscal year, on account of the works to which the same was allotted, to settle claims arising on account of work on contract of date prior to July 1, 1870	16,224 59
Leaving on hand July 1, 1872, which is held to meet similar claims on account of old work, and all of which will be expended or turned into the Treasury during the current fiscal year	2,152 31

EXAMINATIONS AND SURVEYS.

Of the appropriation approved on the 11th July, 1870, for "examination and surveys for improvements on the north and northwestern rivers, &c.," I had—

On hand July 1, 1871		$3,973 75
Of which I have expended, during the last fiscal year ending 30th June, 1872, the sum of		2,658 34
To meet expenses of a survey of Mississippi River, above the Falls of Saint Anthony	$1,187 37	
Of an examination of the bridge over the Saint Croix River at Hudson, Wisconsin	94 75	
Of a reconnoissance of the Chippewa River, below Chippewa Falls	165 30	
And for care of and repairing survey and sounding boats	1,210 92	
	2,658 34	
Leaving in my hands July 1, 1872, of the appropriation above named		1,315 41
And of the appropriation of the 10th of June, 1872, I have received the sum of		5,000 00
Leaving, on July 1, 1872, an available fund for surveys and examinations in the district under my charge, the sum of		6,315 41

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The greater part of which will be applied during the current fiscal year to the expenses of a survey which is now in progress on the Upper Mississippi River.

For necessary surveys in connection with works of improvement under my charge, I would respectfully ask for an appropriation for the fiscal year ending 30th June, 1874, the sum of $10,000.

I transmit herewith a tabular statement of funds showing amounts received and available; also amounts required for fiscal year commencing on July 1, 1873.

All of which is respectfully submitted by your most obedient servant.

J. N. MACOMB,
Colonel of Engineers, U. S. A.,
Engineer in charge and Gen'l Sup't, &c.

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Statement of funds for the fiscal year ended June 30, 1872, in connection with the works under the general superintendence of Colonel J. N. Macomb, Corps of Engineers, United States Army, showing the amounts on hand at the commencement of the fiscal year July 1, 1871; the amounts received and expended during the same time; the amounts available for continuing the works, and the amounts required to be appropriated for the fiscal year ending June 30, 1874.

	Repair, preservation, &c., of river and harbor works.	Examination and surveys on western and northwestern rivers.	Rock Island bridge.	Preservation of Falls of Saint Anthony.	Improving Upper Mississippi River.	Improving Minnesota River.	Improving Illinois River.	Improving Des Moines Rapids.	Improving Rock Island Rapids.	Snag-boats and dredges on Mississippi River.	Examination, surveys, and contingencies of rivers and harbors.	Total.
On hand July 1, 1871	$18,376 90	$3,973 75	$158,778 28	$8,574 17	.....	$96 44	$25,729 90	.....	$18,010 44	.....	.....	$233,539 86
Received during the fiscal year ending June 30, 1872	.....	.....	453,000 00	30,000 00	$47,000 00	10,137 47	29,000 00	$400,000 00	173,000 00	.....	.....	1,142,137 47
Total	18,376 90	3,973 75	611,778 28	38,574 17	47,000 00	10,233 91	54,729 90	400,000 00	191,010 44	.....	.....	1,375,677 35
Due from the United States July 1, 1871	.....	.....	.....	.....	1,935 86	.....	.....	110,944 06	.....	.....	.....	112,879 92
Expended during the fiscal year ending June 30, 1872	16,224 59	2,658 34	586,140 39	36,153 64	44,019 46	10,016 51	51,181 37	288,843 41	191,513 29	.....	.....	1,226,751 00
Total	16,224 59	2,658 34	586,140 39	36,153 64	45,955 32	10,016 51	51,181 37	399,787 47	191,513 29	.....	.....	1,339,630 92
Due to the United States July 1, 1872	2,152 31	1,315 41	25,637 89	2,420 53	1,044 68	217 40	3,548 53	212 53	.....	.....	.....	36,549 28
Due from the United States July 1, 1872	.....	.....	.....	.....	.....	.....	.....	.....	502 85	.....	.....	502 85
Due the United States	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36,046 43
Balance of appropriations remaining in Treasury on July 1, 1872	.....	.....	117,309 57	50,000 00	.....	10,000 00	9,000 00	400,000 00	130,700 28	$42,000 00	$5,000 00	764,009 85
Amount required to be appropriated for the fiscal year ending June 30, 1874	.....	10,000 00	.....	200,000 00	.....	20,000 00	150,000 00	1,000,000 00	108,000 00	72,000 00	.....	.....

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H 9.

ROCK ISLAND BRIDGE.

UNITED STATES ENGINEER OFFICE,
Rock Island, Illinois, August 31, 1872.

COLONEL: I have the honor to make the following report upon the superstructure of the Rock Island bridge.

The general plan having been made and the location of the draw-span definitely settled, general specifications were issued in May, 1870, and bids called for, to be handed in on or before the 6th of July following. These specifications were general in their nature, and drawn up so that the bidders would have equal opportunities to compete for the bridge, no particular form of truss, nor any particular patent being specified, that would debar some firms from proposing, while at the same time the Government would have the benefit of a greater number of plans to choose from, and be better enabled to secure a proper structure. The following are some of the main points of the specifications as issued:

The superstructure will consist of two spans of 260 feet, three spans of 220 feet, fixed in permanent position, and one draw-span, with two equal openings of 160 feet, and a total length of 366 feet.

Each span will consist of two trusses, 33 feet between centers of top and bottom chords, with wagon-road on bottom chords, and single-track railroad intermediate, allowing 12 feet headway for wagon-road. The trusses to be placed 18 feet apart in the clear, with two sidewalks, each 5 feet wide, outside, on level with wagon-road and floor. Moving load, 5,000 pounds per linear foot. Both the fixed and draw spans, as above, must have the material so proportioned in them that the weight of the structure, (including railroad-track, stringers, &c.,) together with the moving load, as aforesaid, will in no part cause a tensile strain of over 10,000 pounds per square inch of section, nor a shearing strain on the pins of over 7,500 pounds per square inch of section. Iron in compression not to be subjected to more than the following strains:

If the column or chord be 10 diameters long, 8,000 pounds per square inch.
If the column or chord be 15 diameters long, 7,500 pounds per square inch.
If the column or chord be 20 diameters long, 7,000 pounds per square inch.
If the column or chord be 25 diameters long, 6,500 pounds per square inch.

The least dimension of the compression member to be used as the diameter. The wrought iron shall be of the toughest and best quality, free from scales, blisters, and other imperfections. Before being used, from each lot of 50 bars there shall be taken indiscriminately three, from which pieces shall be cut and turned down to about one inch area, and these shall be tested by hydraulic pressure to 60,000 pounds per square inch of sectional area, and if either break the lot shall be rejected. Before being placed in the bridge, all the wrought iron shall be tested to 20,000 pounds per square inch of section, and be rejected if showing a permanent set or an extension of $\frac{1}{1350}$ part of its length.

The floor-beams to be of the best quality wrought iron, upon which strains of 8,000 pounds per square inch will be allowed.

No bar of wrought iron having an error in length between the pin-holes of over $\frac{1}{32}$ of an inch, or in the diameter of the pin-hole of over $\frac{1}{100}$ part of an inch, shall be allowed.

All screw-ends of rods must be large enough to give the full section of the rod inside the screw-thread. All metal in the eye-bars, clear of pin-holes, to be 1½ times that in the bar.

The draw-span shall be provided with turn-table of such construction and material as the engineer in charge shall approve, and be worked by steam as well as by hand gear.

The railing of sidewalks to be 3 feet 6 inches high, and strong enough to resist considerable pressure from a crowd.

The test, under these specifications, shall be made by and at the expense of the contractor, but the engineer in charge shall have the power of ordering all other tests within the limits of these specifications, which in his discretion may be deemed necessary to secure the above-specified strength, and of rejecting any part of the work which in his opinion does not satisfactorily bear the tests applied, and which from imperfect workmanship or defective material may be unsuitable.

All workmanship to be of the best quality; all abutting joints to be planed; and all holes in iron to be drilled, except rivet-holes, which may be punched and reamed to fit.

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All iron-work shall be painted with one coat of red-lead and oil before being exposed to the weather, (except the pins, joints, and other machine-cut work, which shall be covered with one coat of white-lead and tallow mixed,) and the whole to be painted with two coats after the bridge is raised.

The specifications also included provision for the camber of the spans and the tests that each span was to stand; also kind and nature of flooring.

Under these specifications, bids were received from the following firms: Kellogg, Clarke & Co., Phœnixville, Pennsylvania; Baltimore Bridge Company, Baltimore, Maryland; L. B. Boomer & Co., Chicago, Illinois; Keystone Bridge Company, Pittsburgh, Pennsylvania; and Detroit Bridge Company.

The plans, &c., having been carefully considered, the award was made to the Baltimore Bridge Company, and a contract entered into on the 13th of October, 1870, for the draw-span, one span of 260 feet and one span of 220 feet, the amount of available funds on hand being only sufficient for these three spans, and current expenses, the remainder of the appropriation having reverted into the Treasury. The contract for the remaining spans over the main river, and the approach-spans at each end, was not entered into until August, 1871, after the money which had reverted into the Treasury had been re-appropriated.

The contract entered into with the Bridge Company allowed the engineer in charge to make such alterations as might be deemed necessary, the Government to have the benefit of any saving that might result from such changes, and to pay any extra cost which they might involve. Under this provision, certain changes were made in some of the details of the superstructure.

Spans.—The general arrangement of the spans is as follows: Commencing on the Iowa side, a span of 196 feet, for railroad only, spans Second and Front streets, Davenport, these streets intersecting at this point. Then follow the double-deck spans across the river, in the following order: One of 260 feet; three of 220 feet each; one of 260 feet; draw-span, 368 feet; finally, a railroad-span of 100 feet, over the wagon-road on island, leading to bridge, making a total length of bridge of 1,845 feet.

The general design of the main bridge is about the same as designated in the specifications. The trusses are double-system Whipple, in which everything but the washers, &c., is wrought iron. The trusses are 33½ feet high between pin-centers, and placed 19 feet apart, allowing about 17½ feet clear space. There are two floors, the upper, for railroad, placed a little below the center of the trusses, and the wagon-floor on bottom chords. On each side of bridge, outside of trusses, on level with wagon-road floor, are footwalks 6 feet wide, protected by substantial railing. About 12 feet clear head-room is allowed for wagons. In the fixed spans of the double-deck bridge the top chord is 20 inches deep and from 22 inches to 24 inches wide, depending upon the position of the panel. Each segment is formed of four plates, 20 inches by 1 inch to 1½ inches thick, connected together at top and bottom by 6-inch channel-bars, filling-strips being also introduced between the channels and plates, in certain of the segments. Spaces are left in the bottom channels, near the ends of the segments, which receive that portion of the post-head which forms the connection between the upper chord and posts. The different segments are connected together by means of tenons formed of portions of channel-bars, like those that connect the plates together. The posts are the "Phœnix" pattern, of 4, 6, and 8 segments, filling-strips being introduced between those flanges which

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are in a plane at right angles to the axis of the bridge. Spaces are left between the strips in each post for the introduction of the web of the upper-floor beam, the knee-braces and the vertical plates forming part of the post-heads and feet. The post-heads and feet are made of rolled iron, and can be better understood from the drawings on sheets 7 and 6. They are riveted to the posts before leaving the foundery. The post-heads are fastened to the upper chord through the medium of small channels, which fit into the spaces left in the under side of the top chord, and to which they are bolted. The post-feet rest upon the lower-chord pins, through the medium of the post-feet. The end posts of each span rest upon chairs which rest on cast-iron bed-plates on top of pier, one end being supplied with rollers to provide for contraction and expansion of the span. The lower chord of these spans is formed of flat wrought-iron bars, with upset ends, formed into an eye, through which holes are punched and drilled for the reception of the pin.

The ties are of flat iron bars similar to the lower-chord bars. The trusses being very high and double intersection, the ties would be very long if made in a single piece; they are accordingly made in two parts and connected together in pairs by pins, the point of connection being about on a level with upper floor. Brackets are placed outside of and fastened to the posts for the ties to rest upon.

The pins forming the different connections are made of cold-rolled iron, and of different diameters, depending upon the service they have to perform.

The upper-floor beams are the Phœnix pattern, 15 inches deep. The flanges of each one, for a distance back from the ends, equal to the diameter of the posts into which they run, are stripped off and the web inserted through the posts and riveted to the flanges. The lower-floor beams are 12-inch channels, in pairs, and run in the direction of the lower chord, taking the pins, the same as the chord-bars. The beams of two adjoining panels are connected together by short 15-inch splice-beams inserted between each pin. These floor-beams form a part of the lower chord, though in computing the cross-sections necessary to resist the tensile strains, these sections were not included, so that they form so much additional strength to the lower chord.

The top and bottom lateral struts are formed of 6-inch channels, in pairs, connected with the pins of the chords by channel-nuts. The diagonal bracing consists of round rods, joined to the lateral braces near their extremities. Curved knee-braces of T-iron connect the posts and top laterals.

The draw-span is a double Whipple, reversed-pin connections throughout. Each of the seven panels of the top chord, from the ends, is formed of two eye-bars, each 9 inches by $1\frac{1}{8}$, to which eyes from 15 inches to 18 inches in diameter are welded; these eye-bars form the outsides of the chord, and are connected together by horizontal plates and diagonal strips, making each segment stiff, and from 20 inches to 24 inches wide, depending upon the position of the panel. The next four panels are made up merely of eye-bars, from 9 inches by $1\frac{1}{4}$ to 9 inches by 1 inch, with eyes $18\frac{1}{2}$ inches, having respectively 4, 6, 8, and 10 bars in a panel. The remaining panel is a short one, and used as a connecting-link between the two arms; it is formed of four pieces, $18\frac{1}{2}$ inches by 1 inch, 5 feet long. Cord-rolled pins, 5 inches in diameter, connect the different segments. (These pins also form the connection between the post-heads and top chord.)

The bottom-chord segments (with the exception of those belonging to the two short panels in the middle of the draw, and which are directly

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over the turn-table) are all of the same shape and arrangement, the difference being in the cross-sections. Each of these segments is built of 4 plates, 12 inches deep on each side, nutted together, except near one end, the connecting between the two sides being a horizontal plate from $\frac{1}{2}$ to $\frac{3}{4}$ inch thick, and from 16 inches to 21 inches wide. Each pair of plates, on the sides, separate at one of the ends, forming a fork, which receives the closed ends of the corresponding plates in the next adjoining segment. Five-inch cold-rolled pins, with collars running through the forks of one segment and closed end of the other, form the connections. (These pins also form the connection between the post-feet and lower chord.) The middle segments are formed of two channel-bars outside, with two bars on each side of the same depth, riveted on the inside, and covered at top and bottom by plates, making hollow beams. The posts, lateral bracing, upper-floor beams, &c., are the same as the fixed spans. The post-heads and post-feet are similar, and like the latter parts in the fixed span.

The turn-table is of cast iron, 30 feet in diameter, 48 inches deep. It is formed of six segments forming the circle, and two acting as a girder, running across at right angles to the upper and lower flanges. Each segment has vertical and diagonal ribs cast upon it, forming on each side something like an ordinary roof-truss. In considering the weight that each segment had to bear, and its consequent strength, the calculation was made as if the vertical and diagonal ribs and flanges alone sustained the weight. The web is therefore so much additional strength. The lower flanges of the outer segments vary in thickness, according to position. Eye-bars (wrought iron) are shrunk upon the lower flanges of the segments forming the girder. The outer segments are braced by heavy diagonals to each other, and to the cross-girder. The circle of the drum rests upon 36 conical wheels, 1 foot wide on tread; outer diameter, 30 inches. These wheels run upon a raised cast-iron track, and are connected by round rods to a collar which is fitted to a central cone, securely fastened to the masonry. The girder also rests upon this cone, through the medium of a steel collar, the table turning around a 6-inch steel pin at the center. This center-pin sustains only a small portion of the weight of the draw, nearly the whole of it being thrown upon the bearing-wheels. The draw is turned by means of a steam-engine and pumps, working a couple of hydraulic jacks, one on each side of the span, and vertical, the cylinder being attached to and supported by the turn-table. Two sheaves are attached to each piston, and two to each frame. One end of a $1\frac{1}{4}$-inch wire rope is attached to the draw, and after running over the sheaves alternately, runs on pins bolted to the masonry at a point a little beyond where the draw will be when it is opened. The other jack is arranged in the same manner, the direction of the rope being reversed. A mixture of glycerine and water is pumped into the first cylinder, the piston of which, moving up, takes the wire rope, and the draw is turned in the direction of the fixed point in the masonry. As this piston ascends, the other descends, and its wire rope is let out, and the mixture of glycerine and water which was in this cylinder is forced back into a receiver at the pumps. To close the draw, the pumping is reversed, the liquid being forced into the latter cylinder, its piston ascends and draws the span to its first position. Gearing is also attached to the machinery, by which the draw can be turned by hand, in case of any accident to the steam-engine. The draw-span has, so far, worked beautifully; no accident has yet occurred. Considering the great weight that is moved, 1,655,000

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pounds, it is a great triumph for the designer, Mr. Shaler Smith, president Baltimore Bridge Company.

A lever at the center of the draw, works the latches which keep the ends in position when closed; these latches are kept in position by heavy springs attached to the bumper-plate.

The ends of the draw are brought to a bearing upon their bed-plates by means of rockers, the throw of which is about 1¾ inches. The rockers are worked by gearing at the ends of the span. The rockers rest upon bed-plates, the top of which can be raised or lowered by means of wedges, so as to conform to any degree of contraction or expansion.

The engine and boiler houses are directly over the side-walks, on a level with railroad-floor; they are framed of wood and covered with corrugated iron. The lower-floor stringers are of pine, 3½ by 12.34 feet long, placed 2 feet apart, resting upon the lower-floor beams. The flooring of the wagon-way consists of oak plank, 4 inches by 5 inches, running in the direction of the axis of the bridge. The side-walks are made of 2 inch by 6 inch oak plank. Two sets of iron tramways, 12 inches wide, are laid upon wagon-road floor. Guard-rails, 8 inches square, are placed on lower floor, just inside of trusses.

For the upper floor a Howe truss is suspended horizontally from the 15-inch beams by means of straps, and, upon these, stringers are laid 7 by 15, 2 feet apart, bringing their tops on level with top of 15-inch beam. A tight floor is then laid and covered with tin, upon which strips of oak are nailed, to which the rails are bolted. A heavy guard rail is placed outside, on each side, which prevents any train from running off of bridge, and keeps the strings in position. The Howe truss takes up in its bearings all lateral shocks from passing trains. Pipes are arranged at the ends of the different spans, which carry off the water that falls upon the decks.

The two approach-spans are single system Pratt's trusses. The top chord is composed of Phœnix-beams connected by cast-iron joint-boxes, pin-connections. The bottom chord of the span of 100 feet is made of channel-bars, while that of the 196 feet is made up of channel-bars and chord-bars, similar to the lower chords of the large spans; 7 by 15 inch ties rest upon these floor-beams. The flooring, guard-rails, &c., are similar to the corresponding parts of the large spans. One end of these shore-spans rests upon shore-abutment; the other end stands upon columns resting upon the river-abutments.

Only a general idea of the bridge has been intended in the foregoing description. For the various details pertaining to the different parts, reference can be made to the drawings which are transmitted herewith. A statement of the drawings, forty-four sheets, in addition to several on paper, will be found annexed.

Erection of superstructure.—The erection commenced on the Davenport side with the first span of 260 feet. Work was commenced in August, 1871; the false work for the span was entirely raised by September 13, and the work immediately commenced. The span was swung clear of false work on 25th of same month.

The false work for the other span was then pushed forward. That of the first 220 feet was commenced September 18; iron work commenced on 5th October, and span was swung on 25th of same month. Work was then commenced on the lower tier, false work of No. 5, and the other spans, so as to have the foundations in before the river closed. False work of No. 2, 220 feet, was completed by November 16; but delays here occurred owing to the non-arrival of the iron for certain parts necessary to com-

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plete the entire span. In consequence of the delay the false work was exposed to the running ice, and on the 4th of December was carried away by the ice. Fortunately there was no part of the iron upon it. Work was immediately recommenced upon the span, and the false work again in place by January 3. Iron work immediately commenced, and span swung on 16th of same month.

On the 3d, 220 feet of the false work was in at the same time as the previous 220 feet, and the iron work commenced on January 15, and span swung on the 26th.

The false work for the draw-span was raised upon the crib-work forming the protection-pier and the material carried out from the island side. Frequent delays occurred in raising this span, owing to the non-arrival of the iron. Early in December the lower chord was laid, and the span swung around to its proper place January 20. Although the lower tier false work of the second 260 feet was in early, the upper tier asw not raised until January 26. Work commenced on the iron February 2, and span swung in eight days.

The approach-spans were put up as soon as the false work from the last spans had been removed.

The entire bridge was finished by the 1st of May, and during that month the Chicago, Rock Island and Pacific Railroad Company commenced running their construction-trains over.

The test of the bridge was made on the 8th of May, Mr. Johnson, chief engineer of the Chicago, Rock Island and Pacific Railroad, representing the railroad company. This gentleman prepared a train for the upper deck, consisting of six flat cars loaded with sand, car and load weighing together 68,000 pounds, and two engines weighing respectively 35 and 30 tons. On the wagon-road floor twenty-six wagons loaded with stone—team, wagon, and driver weighing about 7,800 pounds. One span was tested at a time, the train and wagons then moving upon the next. The following are the results:

Span of 196 feet, (railroad:)

Load	186 tons.
Deflection	1⅞ inches.

First span of 260 feet:

Camber	$2\frac{3}{10}$ inches.
Load	345 tons.
Deflection	$\frac{1}{16}$ inch.
Elongation of bottom chord	$\frac{1}{2}$ inch.

First span of 220 feet:

Camber	1⅛ inches.
Load	297 tons.
Deflection	$\frac{9}{16}$ inch.
Elongation of bottom chord	$\frac{1}{2}$ inch.

Second span of 220 feet:

Camber	2 inches.
Load	297 tons.
Deflection	$\frac{1}{16}$ inch.
Elongation of bottom chord	$\frac{1}{2}$ inch.

Third span of 220 feet:

Camber	2 inches.
Load	297 tons.
Deflection	$\frac{1}{16}$ inch.
Elongation of bottom chord	$\frac{1}{2}$ inch.

Second span of 260 feet:

Camber	2⅛ inches.
Load	345 tons.
Deflection	$\frac{1}{16}$ inch.
Elongation of bottom chord	$\frac{1}{2}$ inch.

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Draw.—One arm, 184 feet long, was fully covered, the load be about 160 tons; the other arm being inclosed, the deflection of the was about $\frac{2}{5}$ inch.

Span of 100 feet, (railroad:)

Load.....95

Deflection.....$\frac{1}{4}\frac{1}{8}$ i

The test was pronounced in every way satisfactory. The load u the bridge was probably much greater than will ever be required. S it was very much below that taken in noticing the calculation of strains, &c., so that we are considerably on the side of safety. the iron used in the bridge was inspected by the specification. I at Phœnixville when the work was being carried on at first. My p then afterward being taken by Mr. George B. Nicholson, who perfor his duty faithfully and thoroughly.

All pieces that did not come up to the standard required were rejec In addition to the above tests, I had pieces from a number of the which were tested in the machine at the Rock Island Arsenal by L tenant W. P. Butler, of the U. S. A., to whom I am much indebted.

The strains upon the fixed spans of the main bridge are calcul upon a basis of 5,000 pounds per linear foot. Upon the single-t railroad-spans, 2,500 pounds per foot are taken.

The usual method of computing the strains upon a draw is by con ering the central bearing as carrying the whole dead load when the d is swinging, and that when closed each arm acts as a separate or dis tinuous span, the maximum strains in the different parts then ta as the proper ones. In most of the large draws already built the str have been calculated in this manner, but the results show that the c putations are erroneous, and that the central parts of the trus especially the ties, &c., are too weak. In the Rock Island draw span is supposed to be continuous throughout, and that when f loaded, the central pier carries the whole dead load of the truss half the live load. Attached hereto are the strain sheets of the la spans, which show the strains upon the different parts of each sp and the consequent metal areas.

Too much credit cannot be given to the Baltimore Bridge Comp for the manner in which they performed their part of the contract, for the excellent workmanship and material that they put upon bridge. And it is to be regretted that they were not so fortunate pecuniary point of view as they were in erecting the *strongest and perfectly finished bridge in America.*

A letter from Mr. C. Shaler Smith, president Baltimore Bridge C pany, will be found hereto annexed, (marked H 10,) giving a few det in regard to the bridge, together with a statement of the weight of different materials, &c., in the bridge.

I remain, very respectfully, your obedient servant,

W. H. H. BENYAURD,

Captain Engineers, Brevet Majo

Colonel J. N. MACOMB,

United States Corps of Engineers.

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H ro.

ROCK ISLAND BRIDGE.

ST. CHARLES, MISSOURI, *August* 8, 1872.

MAJOR: The bridge which we have just completed for the United States Government, under your supervision, being now accepted, I deem it not out of place to recapitulate the principles upon which the work was originally designed, and to call your attention to the successful attainment of the desired ends, and the thoroughness of execution which marks the work.

The conditions imposed by the engineering requirements in the case were these: A wagon-road on the lower floor, together with a railroad-track above, at a level nearly central between the top and bottom chords of the truss. This brought the lateral disturbing element of force at the worst possible place, and the economic depth of truss being but 33½ feet, there was no room for efficient lateral arching between the upper chords. This series of horizontal strains has been successfully met by making the railroad-floor a suspended lateral truss, which checks these strains by its inherent horizontal stiffness, and does not communicate them to the main girders. An additional element of security is gained by passing the web of the railroad-floor beams entirely through the posts and riveting the whole frame together.

To observe your requirement of an entirely wrought-iron truss, we have constructed the top chords of the fixed spans of vertical plates, connected by horizontal channels, which tenon into each other at the posts, thus dispensing with the usual cast-iron joint-boxes, and providing excellent chambers for the reception of the diagonal ties without the necessity of any riveted work in the field.

The posts, which are the usual "Phœnix column," are provided with wrought-iron heads and feet, thus dispensing with the ordinary cast-iron foot-box. Durability of structure is attained by making all wrought-iron sections—especially where inclosed, as in a post—not less than one-half inch thick, whether this was required by the strain or not. The form of truss used, the doublet-system Whipple, was adopted, because the railroad-floor indicated the use of a vertical post, and under these conditions, the Whipple became both the most symmetrical and economical.

I would also call your attention to the fact that all lateral struts are also ties; are hinged in the plane of the truss, so as to provide for the alternate expansion of each chord as the sun strikes them, and that both struts and lateral ties are attached to the same pins which connect the web and chord systems; so that all disturbing strains, whether vertical or horizontal, are checked at the same member, and the quadrangle of force and resistance is complete, without passing through an intervening member, such as a suspension-bolt, as in the cross-floor-beam system, or the cast joint-box in the usual practice of placing the strut on the top of the upper chord.

The draw-span presented some peculiar difficulties of construction. Being directly in the lee of the arsenal building, and having two heavy floors, the effect of the wind on it was an unknown quantity, while the weight of the moving parts, some 1,530,000 pounds, was considerably greater than had ever before been placed on a turn-table. Bearing these facts in mind, and desiring also to avoid any over-concentration of weight on the masonry, four-fifths of the weight were placed on the bearing-wheels of the table, and the remainder on the center-pin. In view of

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the difficulty of replacing broken gearing of the size required to m
this immense weight, hydraulic power was selected as the moving ag
the rams being placed vertically on the table, and an inch and a qua
wire-rope being used for the transmission of power. This rope is
posely weaker than the rest of the machinery, so as to confine breaka
to it if possible. The pumps are worked by a 10 by 5 inch engine,
a mixture of glycerine and water used for the fluid. Experiments m
with the draw, on a calm day, show that the momentum of this e
mous weight is so great that it is unsafe to move it at the cont
speed of opening or shutting in two minutes, and that motion at
rate of 14 inches per second, of the outer end of the truss, is all
should be allowed. The rolling friction of the wheel-circle is found t
8 pounds, nearly, in the thousand of superincumbent weight. Thi
an interesting fact, as no previous data exist on this subject, and
experiments with a small machine, made for the purpose, gave
pounds per 1,000 as the probable result. The draw-truss itself is
inverted double Whipple, and is believed to be the first instance
purely skeleton girder in existence.

All connections are made by pins, posts with chords and ties, and ch
with each other, so that no riveting is required during erection.

The truss is proportioned upon the hypothesis that when fully loa
the center pier carries the *whole* weight of the truss and five-ninth
the live load, thus requiring about one-fourth more section in the cen
members than trusses computed in the usual manner, but offering
great advantage of sufficient strength, should the attendants neglec
raise the ends before the passage of a train. The approach spans
single-system Pratt's, but are built with the same care, as to details
in the main bridge. One end of each of these spans is fixed to the a
ments, while the other stands on a rocker 13 feet high, the bottom c
of which is a segment of a circle of 26 feet diameter. This presen
curious appearance when the draw is open, but the system is perfe
correct, both in theory and practice. The exact amounts of materi
the different spans are as follows:

Each 260-foot span:

Iron work, pounds	74
Pine lumber, (69,594 feet,) pounds	20
Oak lumber, (28,860 feet,) pounds	11
Spikes, pounds	
Tramway, iron, pounds	2
Total	1,09

Each 220-foot span:

Iron work, pounds	54
Pine lumber, (54,855 feet,) pounds	16
Oak lumber, (24,442 feet,) pounds	9
Spikes, (2,640) pounds	
Tramway, iron, pounds	2
Total	83

Draw-span:

Iron in span, pounds	85
Iron in turn-table, pounds	20
Iron in machinery, pounds	1
Iron in engine-house, pounds	
Iron in spikes, pounds	
Iron in tramways, pounds	3

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Pine lumber, (99,088 feet,) pounds	294,264
Oak lumber, (40,626 feet,) pounds	162,504
Total	1,565,465

Two-hundred-foot span:

Iron work, pounds	238,857
Ornaments, &c., pounds	5,243
Pine lumber, (20,213 feet,) pounds	60,639
Total	304,739

One-hundred-foot span:

Iron work, pounds	75,953
Ornaments, &c., pounds	3,402
Pine lumber, (12,513 feet,) pounds	37,539
Total	116,894

The total weight, therefore, of the ordinary construction materials, not including railings, &c., is 6,675,000 pounds. Believing this to be, by far, the strongest and most perfectly finished bridge in America,

I remain, yours truly,

C. SHALER SMITH,
President Baltimore Bridge Company.

Major W. H. H. BENYAURD,
In charge of Rock Island Bridge, Rock Island, Illinois.

H 11.

ROCK ISLAND BRIDGE.

OFFICE OF UNITED STATES ENGINEERS,
Rock Island, Illinois, July 1, 1872.

COLONEL: I have the honor to make the following report of work done on the substructure of the Rock Island bridge during the year ending June 30, 1872.

The old coffer-dam, at the site of pier No. 5, was dredged out, and a new and very substantial coffer-dam of larger dimensions put in. This new dam served its purpose admirably, and the excavation through the bed of bowlders down to the rock-bed of the river, which was from 7 to 10 feet below the bottom of the coffer-dam, was made without interruption, and pier No. 5, founded on the rock, was carried up to completion.

The two railroad-abutments have been finished, and the two main abutments built up a few inches higher, to meet the requirements of the superstructure.

On the 2d of November a coffer-dam was commenced for the purpose of blasting out about 3,000 yards of rock in the south-draw channel. On account of bad weather, and the freezing over of a part of the river, this dam was not completed and pumped out until the 24th November. The excavation of the rock then progressed until December 1, when the gorging of the ice in the river, which had frozen over at an unusually early date, broke in the dam, and suspended all operations for the winter. About 1,000 yards of rock had been removed when the break occurred.

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Preparations are now being made for replacing this dam and completing the work of excavation.

The bridge is now essentially finished. All that remains to be done is the grading of the approaches, the laying of walks from the abutments to the outer line of Front street, in Davenport, and the building of a protection-wall along the top of the slope of the Davenport approach.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Captain of Engineers, Brevet Major, U. S. A.

Colonel J. N. MACOMB,
Corps of Engineers, United States Army.

H 12.

PRESERVATION OF THE FALLS OF SAINT ANTHONY.

ROCK ISLAND, ILLINOIS, *April* 5, 1872.

GENERAL: At the time of making my annual report in September, 1871, it was understood that a new estimate for the preservation of the Falls of Saint Anthony would be presented, based upon the results of a survey then in progress.

I beg leave now to present a report from my assistant, Mr. Franklin Cook, civil engineer, who has had the local charge of the works at that point.

I send, at the same time, two sheets of tracings of the maps of the survey and project; the one being a map (on a scale of 200 feet to an inch, or $\frac{1}{2400}$) of the vicinity of the Falls of Saint Anthony, and of the river for some four miles above the falls. The other sheet gives (on a scale of 20 feet to the inch, or $\frac{1}{240}$) a plan showing details of head of limestone ledge, and of river-bottom above the natural barrier, and of our work, in the way of coffer-dams and permanent wall, that has been executed at the breaches into the head of the tunnel. This sheet shows also the site of proposed wall at the head of the ledge, with sections or profiles, (vertical scale 4 feet to an inch, or $\frac{1}{48}$,) and an exhibit of the result of the boring, showing the stratification to a depth of 148 feet.

This survey, with the experience of the last season, shows, I think, the proper method to be pursued in the future works for the preservation of the falls, and indicates the plan for protecting the natural barrier which is proposed in the within report. The success of this plan, after all, must depend upon keeping in good repair the protecting *apron* on the lower side of the natural barrier—a work which has been chiefly constructed by the owners of the water-power on the two sides of the river; and the condition of that work, when I last saw it, was such as to impair my confidence in its permanency, a consideration which causes me great misgiving in presenting this project, especially as to the eventual cost of the works which may become necessary for the preservation of the Falls of Saint Anthony.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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MINNEAPOLIS, MINNESOTA, *November* 28, 1871.

COLONEL: In closing up my work this season I have the honor to submit to you the following report of work carried on by me, under your directions, for the preservation of the Falls of Saint Anthony.

On the 14th of April last I received your orders to commence and carry forward the work, begun last season, of closing up the gorge through which the water broke into the tunnel, at the foot of Nicollet Island, and build a coffer-dam from the east side of Nicollet Island, to join the old Saint Anthony Dam, 120 feet east of where the coffer-dam was joined to the same last fall.

This dam, 430 feet in length, I completed about the middle of May. I then commenced clearing out the *débris* from the gorge at the place I had left to cross with my permanent wall of masonry. My pump worked well, and kept the pit clear, and everything worked favorably till I had reached within 2 feet of the bottom of the gorge, when a leak commenced in the pit that I was excavating for my wall. It came through the soft stratum of sand near the bottom of the gorge; the water coming in under the coffer-dam, and appeared to pass through among the loose stone in the bed of the river, and increased to such an extent as to prevent me from prosecuting my work at that place. I at once filled up the place I had opened, and commenced filling out on the earth embankment, inclosing the coffer-dam around the head of the gorge, to close the leak.

The water appeared to be so diffused, passing through the broken stone forming the bed of the river over which the coffer-dam and embankment were built, that I was not able to determine the exact place where the water came under the dam.

I extended the embankment on the outside into the river and up stream from 60 to 100 feet, lapping it on the limestone ledge about 35 feet. On top of the embankment I piled up broken stone 5 feet high, making a very heavy and, it seemed to me, secure protection against any further breaking in of water from the river.

I then commenced clearing the *debris* out of a section 50 feet long at the lower end of the first break, intending to go down to the bottom at that place and build a wall of masonry across the gorge, and puddle up a sufficient distance to make a secure dam, then go back and commence at the head of the gorge and make another effort to clear it out and put in my wall of masonry, having the above wall for protection in case of accident. After getting this place cleared out to within about 2 feet of the bottom, the water broke in, coming along on the bottom on the westerly side of the gorge. I at once tried to find the place where the leak came in under the head of the coffer-dam, and, after examining the bed of the river two days, I found a place about 20 feet outside of my embankment inclosing the coffer-dam. The usual depth of water in this place was 14 feet, while, for a space of about 3 feet across, the water was 20 feet deep. I at once ran out an embankment from the one built previously, and, in closing over this deep place, the leak stopped, so that there was much less water running through the tunnel than at any previous time. It appears that this leak occurred by the water coming in under a stratum of the sandstone under the embankment, thus preventing the material in the embankment from falling in to choke up the place through which the water passed.

After closing up the leak, as above stated, I commenced clearing away that part of the timber coffer-dam above the head of the ledge, and removed the earth embankment immediately above it, so that I might get down to the sandstone under which the water had found its way into my works. I cleared away a space 110 feet out in the stream from where I was intending to put in my permanent wall of masonry, still leaving sufficient embankment outside for a good substantial coffer-dam. After clearing away all the material down to the sandstone that had formed the bed of the river, and removing the *debris* from the gorge as low down as I could go without pumping out the water, which was standing in the gorge 7 feet deep, I then determined to clear out a section of the gorge, and chamber into the sandstone on either side to where it was solid. On the up-stream side of this place which I cleared out, I dredged the loose material out of the gorge, and excavated chambers in the sandstone on each side down to the water, then bored out the sand with six-inch augers, cutting out the interstices with a large chisel made for that purpose. These trenches were carried down to the hard layer of sandstone which formed the bottom of the gorge. This work was very slow and tedious. I opened these trenches 10 inches wide and 50 feet long. I then filled them up, and the section across the gorge, connecting them with a concrete wall to the surface of the water, making the concrete part of my wall 7 feet high, and then built up 4 feet of stone masonry on top of it, bringing the wall up even with the top of the sandstone on the sides of the gorge, leaving a gap on top of the concrete wall, through which the water might pass that I had cut off, which had been coming in through the sides of the old gorge.

After getting the wall completed, I put my pump in the gorge below this last wall, and drew the water down and cleaned out the *débris* and sandstone to the bottom of the gorge; this sandstone having been undermined by the water passing underneath it, making it necessary for me to make my excavation 40 feet wide to clear out to

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where the sandstone was solid. I then filled up this section with clay and gravel-puddle, having it thoroughly tamped down as the filling progressed. After getting this cleaned out and partly filled up, I commenced clearing out the gorge at the place I had left to put in my permanent wall of masonry to join the walls already commenced. I had successfully cleared out the *débris* to the bottom of the gorge, and commenced the foundation of the main wall on the hard stratum which forms the bottom of it. In clearing the *débris* out of this section of the gorge, I found that the sandstone on the northerly side of the gorge had been undermined, so that it became necessary to clear out a section 30 feet wide in order to get a good foundation for my main wall. I also excavated a trench in the sandstone on the southerly side of the gorge, so that I might put in a wing-wall to prevent the water from finding its way around the end of my main wall. After getting in about 20 feet I struck a small cavity, through which the water had evidently passed. It was at this time nearly dry. I continued building up the foundation of my main wall, intending to get that as high as the ledge, and then extend my wing-wall out across this last cavity.

At this time, the 16th day of September, a new stream of water started in from the river through this last-found cavity, discharging through my trench which I had excavated to the cavity from my main wall, discharging out over the foundation that I had already laid in the gorge, which at this time was 5 feet high. This stream was about 2½ feet deep, by 2 feet wide, where it came out of the trench I had excavated for my wing-wall. I found that this leak came in from the river on the outside of the embankment which I had extended out to close the leak that occurred the last of June. I at once laid my track, and commenced putting in gravel, and in about a week succeeded in shutting out the water, and again resumed my regular work of building up my main wall and making the fill above it. This work I have continued, and now, this 23d day of November, have completed the main wall across the gorge, and have the embankment above it well protected with riprap, and joined coffer-dam to wall on the southerly side of the gorge.

The foregoing is a report of work as carried on at the head of the original break into the Nicollet Island tunnel. In addition to the above, I have carried on the following work, in accordance with your instructions when you were here last July, to meet the new state of affairs caused by the break into the tunnel, which occurred on the night of the 3d of July. The new break commenced near the center of the channel, between Nicollet Island and the Saint Anthony shore of the Mississippi River, at the head of the ledge, thence passing along under the ledge, in the bed of the river, entering the old tunnel immediately under the foot of Nicollet Island, at about the same point where the first break entered it. I at once got my men together and built a dam from the head of Nicollet Island to Boom Island, which turned all of the water into the main channel of the river on the westerly side of Nicollet Island, leaving the Saint Anthony mill-pond dry, and revealing the break under the ledge, making a chasm about 18 feet wide and about 8 feet deep from the ledge to the *débris* in the bottom.

Another new feature in the case is, that the lower end of the old tunnel became so choked up that the water forced its way out into the river on the westerly side of Hennepin Island, coming out under the ledge about 50 feet below the apron. The outlet is about the same width as the inlet. I immediately notified you of the new break, and received an answer that you would be in Minneapolis in a few days. Upon your arrival, a few days later, I received instructions from you to surround this new break with a substantial timber coffer-dam, and clear out the *débris* from, and put a bulkhead of masonry across, the head of the gorge, and, at the same time, to clear the *débris* out above the bulkhead-wall a sufficient distance to make a good puddle-wall.

By the 31st of August I had built a coffer-dam around the break high enough to keep out ordinary water, and in good condition to raise high enough to stand against a freshet if it should come. I commenced building the dam on the easterly side of Nicollet Island, 130 feet above the head of the ledge in the bed of the river, extending it out into the river at nearly right angles to the shore-line of the island 190 feet, then turned nearly a right angle, running down stream 145 feet to the head of the ledge, then extending on top of the ledge 150 feet in nearly the same line as the last, then extending it 270 feet and joined on to the northeasterly corner of the dam built last spring from Nicollet Island to the old Saint Anthony dam, making a total of 755 feet of coffer-dam built on account of this last break in the Saint Anthony mill-pond. I had also cleared out the east side of the bed of the river, from the Saint Anthony shore to the coffer-dam and the space covered by the coffer-dam, extending it from the ledge up-stream 160 feet, and had given it a good bed of puddle, well paved and riprapped up even with the top of the limestone ledge. I also cleared out the *débris* from the upper end of the gorge, and so up, including most of the space inclosed by the coffer-dam above the head of the ledge, and had built a wall across the head of the gorge, and extended wing-walls out into the sandstone from the main wall easterly 20 feet and westerly toward Nicollet Island 84 feet, and had sloped out the sandstone at the head of the gorge above the wall, and filled up with puddle 9 feet deep, so that it was nearly level with the average of the sandstone in the bed of the river above, making

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it ready for the last coat of puddle, paving, and riprap. The amount of money expended on account of the above-described work was $15,000.

On the last day of August the citizens' committee were organized and ready to go to work; and I turned over the work in the Saint Anthony mill-pond to them, in the condition as above described, and gave my entire attention to closing up permanently the head of the gorge on the westerly side of Nicollet Island, as described in the first part of this report.

When you were here in July last, and had observed the difficulties that attended our work, on account of the leaks into our excavations that were being made for the purpose of clearing the *débris* out of the gorge to receive the permanent walls and filling, you directed me to make a careful survey of the bed of the river to ascertain the location of holes in the bed of the river through which the water might come under the upper stratum of sandstone; also to extend my surveys up stream far enough to ascertain if there was any hard foundation in the river above, where it would be feasible to build a dam in case the falls should go out.

I extended my surveys up as far as the north line of section 3, township 29, range 24, west of the fourth principal meridian, 4.07 miles from the Falls of Saint Anthony, and made examinations eight miles farther up stream to Coon Rapids.

I also made borings in the sandstone to ascertain the depth and character of the sandstone formation.

I have noted the result of my soundings and borings on the accompanying maps. It will be seen that next below the limestone ledge there is a stratum of clay and shale 2 feet thick. This stratum is impervious to water. Next below the clay there is about 4 feet of sandstone that is quite hard, from the infiltration of alumina and carbonate of lime from the stratum above. Then there is about 2 feet of sandstone marked with oxide of iron. The next 6 feet below is white sandstone, made up of thin layers and not homogeneous. Between this and the next stratum (which is quite hard) there is a thin seam of very soft sand, with scarce any adhesion of its particles. The next 6 feet is hard, and withstands the washing of water or atmospheric changes when exposed. This is the hardest stratum of any that we find, as far as I have been able to observe. The top of it is 14 feet below the bottom of the limestone ledge. Next under this are two layers of 8½ feet each of medium hardness, with a soft, thin layer underlying them. Below this the sandstone appears to have been deposited in a more homogeneous mass than that above, and with few well-marked and continuous horizontal seams. This last division of the sandstone is about 49 feet thick. Next below we find a stratum so hard as to require drilling to penetrate it. This is cemented with alumina and iron, and is about 8 feet thick. This rests upon a stratum of blue clay 3 feet thick. Underlying this I find coarse-grained, friable, white sandstone, 27 feet thick; then 10 feet of sand and clay, very hard; then 4 feet of soft, yellowish sandstone; then I struck hard, bluish sandstone, which appears to have been cemented with clay and iron. It was very hard drilling, so much so that, after drilling about 10 feet, I gave it up. This last drilling was 148 feet below the bottom of the limestone ledge, and appears to be the last of the soft sandstone formation. As the cementing material appears to be similar to that found in the Potsdam sandstone, I think this hard stratum extends down to the old red sandstone.

I made a boring at the clay-bed one and a half miles above our works at the head of the ledge. This boring extended down 34 feet lower than the bed of the river at that place, which would be about 80 feet below the bottom of the ledge if it was in place there. I did not find any sandstone in place, but found drift-sand and clay. The bottom of the hole was in a layer of sand so soft that it would fill up the boring so that I could not go deeper without tubing the hole.

I found the sandstone in place, back some distance from the river, on both sides. This last boring shows that the sandstone in the bed of the river has been washed out at some former time, and its place now filled with drift-sand and clay. This washing out appears to extend down to within about one and a half miles of the falls.

The dip of the ledge, from the suspension-bridge up as far as my surveys extended, appears to be about 15 feet to the mile, the dip, or inclination, being down stream and slightly to the westward.

Estimating the top of this hard layer to be 86 feet below the bottom of the limestone ledge, the dip, or inclination, would bring it to the surface of the water about five and three-fourths miles above the suspension-bridge. As this stratum is thin, and has a very soft, friable stratum of sandstone below it 27 feet thick, it would not make a very reliable foundation.

If this dip continues up stream at the same rate as above, we should find the next hard layer at a point about nine and one-fourth miles above the suspension-bridge, which would be the first place where we would be likely to find a reliable stratum in the bed of the river above, and to which place the rapids would no doubt extend if the falls should go out.

I extended my examinations to this place, and the general appearance of the river and rapids tends to corroborate the correctness of the above theory.

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Our surveys, and the experience that we have had in carrying on our work during the past season, show conclusively that we have a very difficult task to preserve the Falls of Saint Anthony, and that it will require a much larger expenditure than at first contemplated, to make them secure against wearing away or undermining by the water getting under the ledge and washing out the sandstone and letting down the ledge. This last difficulty seems to be the most formidable one presented at this time, and the one requiring immediate attention.

It will be seen by the accompanying map that the action of the water has formed deep cavities in the bed of the river above the head of the ledge, and that they have worn down to, and, in some cases below, the soft seam that we find 14 feet below the bottom of the limestone ledge; and our experience this season has proved conclusively that the water has found its way through this soft seam into our works wherever we have excavated down to it in clearing out the *débris* to put in our permanent works to close up the tunnel.

The clearing away the head of the gorge and tracing it out into the bed of the river shows that the first break into the tunnel was caused by the water finding its way into this soft seam in a cavity in the bed of the river, and following along the seam which was cut off by the excavation of the tunnel, the bottom of which was on the hard stratum immediately below this soft seam, the water percolating through moderately at first, and then increasing rapidly as soon as it had displaced sand enough to have a clear channel through from the bed of the river to the tunnel.

It was this same layer through which the water came into our excavation when the leaks occurred, spoken of in the first part of this report. After finding out that the leaks came in under these upper strata, I had determined to clear out a trench at the head of the gorge down to this hard layer, with the water standing in the gorge to the depth of 7 or 8 feet, and put in a concrete wall as an experiment, to see if the water could be closed back in this way, while I pumped out and made the excavation for the foundation to the main wall, across the gorge, which I did, and found this mode of closing up this leaky seam worked successfully.

In the gorge, where the water flowed through into the tunnel in a large volume and unobstructed for several days in succession, there was very little wear in this hard stratum which formed the bed of the gorge and tunnel. This fact, together with the appearance of this hard stratum in the bluffs below the falls, where it is exposed to the action of the frost and atmosphere, shows that it is the hardest and most reliable stratum for a foundation that we have near the top of the sandstone formation.

It seems to me that the most feasible way to prevent further leaks into the tunnel and to guard against the water finding its way under the ledge and coming out at the brink of the falls, thereby rendering the destruction of the falls certain, would be to commence a wall at the southerly side of the main wall that I have built across the gorge, and carry it across the entire width of the river near the head of the limestone ledge, commencing the foundation on this hard stratum 14 feet below the bottom of the limestone ledge, bringing it up even with the top of the ledge, and joining it on to the same. I would break off the ragged edge of the ledge, and quarry it off down to where it was from 2 to 3 feet thick, and then excavate my trench and put in my wall.

It might be thought best, and it would probably be practicable, to sink this trench and extend the wall down deeper into the sandstone, so that the bottom of the wall would be lower down than the cavities in the bed of the river above.

In places where the sandstone above the wall had been undermined and washed out and made porous by the action of the water, I would take it out from 50 to 100 feet above the wall, and fill this excavation with a good clay and gravel puddle, having it well paved and riprapped, to protect it from being again washed out by the action of strong currents in the river at times of high water. I would build a coffer-dam out into the river, about 400 feet above the head of the ledge, where it would cut off the cavities in the bed of the river that have worn down into and below this soft, leaky stratum, carrying it out near the middle of the river, and turning and running down stream and join on to the head of the mill-companies' dams, thus closing the water out of the river-bed half the width of the river and 400 feet up stream, giving a good opportunity to fill up the bed of the river with puddle, paving, and riprap a sufficient distance above the head of the ledge to prevent the water from ever wearing down cavities in its bed, so as to get under the proposed wall at the head of the ledge.

This wall I would extend into the banks of the river sufficiently far to prevent the water from finding its way around the ends, and protect the ends with wing-walls in the manner which would seem the most likely to accomplish the desired object.

The above-described work I estimate will cost $200,000.

Our surveys have also pointed out to us the cause of the wearing out of some of the deep cavities in the bed of the river, and permitting the water to come in direct contact with the soft, leaky seam.

The broken lines on the accompanying map will show the location of the large pier which formerly stood at the head of the ledge, where the wing-dams united near the center of the river. Immediately above the pier there are two deep cavities worn in

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the sandstone, and there is no doubt but what this wearing out was caused by a heavy jam of logs forming on this pier and extending up stream, over the site of these cavities, the logs obstructing the current of water, turning it underneath the logs and impinging a strong current of water directly against the sandstone in the bed of the river, and thus excavating these deep cavaties. No doubt but what the other cavities in the bed of the river were produced by the same cause.

The pier, marked in the accompanying map in the up-stream side of my embankment, no doubt caused the excavation of the cavity from which the original breach into the tunnel found its way. The large cavity in the bed of the stream nearest the easterly shore of the river was formerly the site of a large boom-pier, which held a jam of logs until it formed a cavity which undermined the pier and let it tilt into the cavity, discharging the ballast and allowing the hulk of the pier to float away.

I think the mill companies should be required to remove all of these piers from the bed of the river above the head of the ledge as far up as the suspension-bridge, and the bed of the river should be riprapped around those piers above the suspension-bridge, so as to prevent any further forming of cavaties around them.

In my report to General Warren, dated December 7, 1869, I gave a description of the limestone formation at the Falls of Saint Anthony, and the causes that were operating to destroy it, and description and estimates of works necessary for its preservation. Also report and estimates for lockage to continue navigation past the falls, with description of the ownership of property adjacent to the falls, to which I would respectfully refer, as the foregoing is supplementary to it. It may be found in House Executive Document 118, Forty-first Congress, second session.

I am, colonel, very respectfully, your obedient servant,

FRANKLIN COOK,
Engineer in local charge of work for Preservation of Falls of Saint Anthony.

Colonel JOHN N. MACOMB,
Colonel of Engineers, U. S. A., Engineer in charge of surveys and improvements of the Upper Mississippi River.

H 13.

PRESERVATION OF THE FALLS OF SAINT ANTHONY.

Proceedings of the board of engineers convened in pursuance of the following order, viz:

[Special orders No. 91.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., July 31, 1872.

* * * * * * *

2. A board of officers of the Corps of Engineers, to consist of Colonel J. N. Macomb, Lieutenant-Colonel J. D. Kurtz, Major G. Weitzel, Major O. M. Poe, Major D. C. Houston, will assemble at Minneapolis, Minnesota, on the 10th August next, or as soon thereafter as practicable, for the purpose of considering and reporting upon the whole subject of the preservation of the Falls of Saint Anthony, and of the work now in progress therefor, as will be more particularly stated in instructions of this date, from the Chief of Engineers.

By command of Brigadier-General Humphreys.

JOHN G. PARKE,
Major of Engineers.

The board met at 9 a. m. on the 10th of August, all the members being present. The day was passed in making a personal examination of the falls and the works executed for their preservation. In the evening a large number of citizens called upon the board at the Nicollet House, and presented their views as to the proper method of securing the falls from further injury.

Upon the 12th the board met at 9 a. m., and, after consultation, agreed upon the following

REPORT.

The Falls of Saint Anthony are caused by the damming up of the waters of the Mississippi by a natural barrier, consisting of a layer of limestone-rock, which is 11 feet thick at the crest of the falls and 3 feet

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thick at its upper end, about 1,000 feet above the crest, overlying a mass of sand-rock about 100 feet in thickness. The total fall is 50 feet. The river passes over the ledge in two channels, separated by Hennepin Island. It is apparent that the crest of the falls has been continually receding, and the record shows that the crest near the middle of the river is from 300 to 600 feet above its location in 1857.

The cause of this is found in the action of the water in undermining the sand-rock which sustains the limestone-rock, so that the latter, becoming unsupported, breaks off by its own weight. Unless this action is arrested by artificial protection, the falls will continue to recede until the limestone-ledge entirely disappears, after which, the bed of the river being soft rock, the falls will be destroyed and the bed of the river worn down until the velocity is so reduced as not to wear away the sand-rock.

The water-power caused by the falls has been utilized by dams, canals, and works, the position of which are shown upon the accompanying map. These works have been so located as to increase the destructive action above referred to, by unnecessarily contracting the water-way by which the waste water passing over the falls west of the island is made to converge upon the bed of the river across a space but 200 feet in width.

In addition to the causes of destruction just mentioned, the falls are threatened with danger by the passage of water under the limestone ledge from above, by which the soft sand-rock is worn away so as to allow the limestone-rock to cave in. This danger was developed by the opening of a tunnel from the foot of the falls at Hennepin Island, up to and under Nicollet Island. The water of the river found its way through the soft strata of sand-rock, under the limestone, to such an extent as to wash out large quantities of the soft rock and allow the lime-rock overhead to cave in. Unless this flow had been checked it would doubtless have soon resulted in the destruction of the falls.

From this statement it appears that two things are necessary for the preservation of the falls: first, to prevent the wearing away of the sandstone at the foot of the falls; second, the permanent stoppage of the current from above the falls through the soft sand-rock under the limestone ledge.

The works already executed for this purpose are a timber-apron at the foot of the falls, partially completed, and the construction of a coffer-dam and masonry wall around the gorge caused by the water finding its way into the tunnel. These works are fully described in the report of Colonel Macomb, to be found in Senate Ex. Doc. No. 59, Forty-second Congress, second session.

In addition to the above-mentioned works an effort is being made by the citizens to line the tunnel and fill up the gorge at its head. This plan is described in the accompanying communication, marked X.

In the opinion of this board the plan proposed for the preservation of the falls by Colonel Macomb, in his report to be found in the executive document just referred to, is the correct one, but it involves a cost far in excess of the funds now available. The large interests involved in the preservation of the water-power demand that the works for the purpose of stopping the flow of water in the tunnel should be of such a character as to be rapidly executed, and be of sufficient stability to resist the action of probable freshets.

Having accomplished this, the works for the permanent preservation of the falls can be executed without interfering with the water-power or being constantly exposed to disaster threatening the integrity of the

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falls. This permanent improvement should not be commenced without an available sum of $200,000.

The board is also of the opinion that the apron at the foot of the falls, when completed, will prevent the undermining of the rock and injury to the falls on that side, but deems it important that such modification of the dams and other works be made as will restore the water-way to its natural width.

The board would therefore recommend that the present appropriation be expended in strengthening, as far as necessary, the coffer-dams already built around the gorge, including the work done since July 1, 1872, so as to secure them against freshets, and in continuing the lining of the tunnel on the plan already adopted. It is believed that the immediate danger will be thus avoided. While this work is in progress a thorough study should be made of the details of the plan for the permanent preservation of the falls.

The board would recommend that the sum of $37,500 of the present appropriation be applied in accordance with the petition of the citizens of Minneapolis addressed to Colonel J. N. Macomb, dated July 11, 1872, and as that petition asks that the money be expended under the direction of Mr. J. T. Stevens, engineer of the union committee, the board recommends that, if consistent with the law, the said Stevens be called upon to give bonds for the faithful disbursement of the funds.

The board would further recommend that the balance of the appropriation be expended under the direction of the engineer officer in charge of the works constructed by the United States, in maintaining and strengthening them, as far as is found necessary. The board are led to these recommendations because the sum appropriated is too small to apply with advantage on the plan recommended by Colonel Macomb. They deem it advisable to test the method of lining and plugging the tunnel on the plan adopted by citizens of Minneapolis, upon which a large sum has been expended, especially as the board is informed that, in case the Government funds are thus applied, the additional funds required to complete their plan will be furnished by the city of Minneapolis.

In conclusion the board cannot too strongly condemn the practice, which prevails so commonly throughout the country, and of which the locality now under consideration affords a manifest instance, of erecting structures in and across the natural water-way of navigable streams by the authority of State or States, or municipalities, and sometimes even without any authority whatever, and in all cases without any authority from Congress.

The board therefore recommends that the attention of Congress be invited to this matter, with a view to such legislation as will cause these objectionable structures to be removed or altered, and to prevent their erection in future.

Respectfully submitted.

J. N. MACOMB,
Colonel of Engineers, United States Army.
J. D. KURTZ,
Lieutenant-Colonel of Engineers.
G. WEITZEL,
Major of Engineers.
O. M. POE,
Major of Engineers.
D. C. HOUSTON,
Major of Engineers.

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H 14.

PRESERVATION OF THE FALLS OF SAINT ANTHONY.

To Colonel J. N. Macomb, Lieutenant-Colonel J. D. Kurtz, Major G. Weitzel, Major O. M. Poe, and Major D. C. Houston, United States Army, board of Government engineers, on the preservation of the Falls of Saint Anthony:

The undersigned, of the "Board of construction for the preservation of the Falls of Saint Anthony," and of the "Union Committee" of citizens for the same purpose, and in behalf of the citizens of the city of Minneapolis, respectfully submit that each of the above-named boards have had in charge portions of the work undertaken by the cities of Minneapolis and Saint Anthony, and the Saint Anthony Water-power Company, and the Minneapolis Mill Company, for the preservation of the falls.

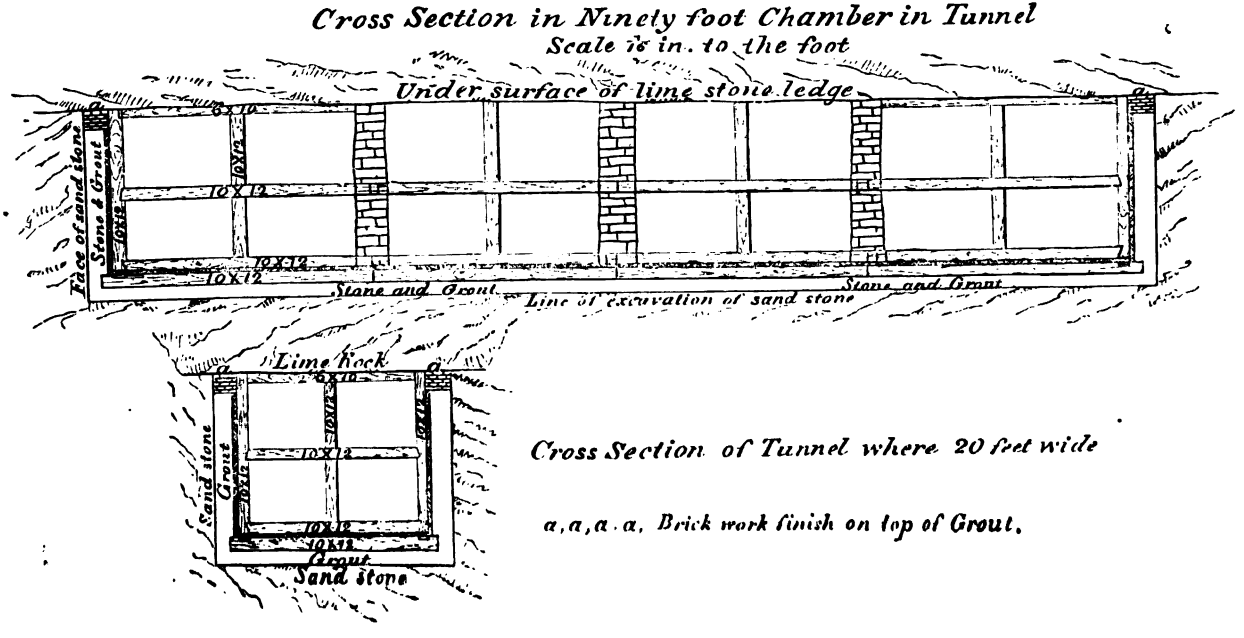
That the "board of construction" was authorized to construct an apron of timber and rock at the falls, to conduct the water from the brink of the same, and protect the soft sand-rock which underlies the lime-rock, from being worn away by the under-tow of water, and have expended in the construction of this apron about $140,000, appropriated by said cities and water-power companies, with a small amount from a late Government appropriation, and have so far completed the work as to have arrested the recession of the falls. They have in hand funds sufficient to place the structure beyond immediate danger. It is estimated that a further expenditure of $65,000 will complete this structure.

The "Union Committee" have had in charge the arresting of injury to the falls, occasioned by the breaking of the river into a tunnel excavated from below the falls upward underneath Hennepin Island, and extending to the lower end of Nicollet Island. This committee have expended about $95,000 in the prosecution of their work, which was also provided by the city of Minneapolis and private citizens.

The expenditure has been made under the direction and pursuant to the plan of J. T. Stevens, an engineer of said committee, and in obedience to the pressing demand for the protection of the tunnel against further damage from freshets, regarding *that* the point of greatest immediate danger, and in view of the fact that the Government appropriation was insufficient to go on with the work in progress at the head of the ledge, and at the same time effectually close up the tunnel. After a thorough examination of the work to be done it was concluded that the only way to do any work that would be durable, and render *immediate* protection, was to *plug* the tunnel, as all work at the head of the break demonstrated that it was impossible to hold the head of water in the sandstone without a base of several hundred feet.

The mode of doing this work was as follows: First, all *débris* and loose rock were excavated and removed from the tunnel, and the sides then cut perpendicular in the solid sand-rock and the bottom level, commencing at the lower end. The bottom of the tunnel was then covered with grout, composed of broken rock and the best water-cement, as the work advanced, on and in which sills of 10 by 12 inch timber were laid, and on the sides posts of the same size timber were erected on the ends of the sills reaching and wedged to the lime-rock above, with supports across the tunnel, at the middle and top, to withstand pressure from without, and distant from the sand-rock from 12 to 30 inches. Outside of these posts 4-inch plank were carried up from the

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Cross Section in Ninety foot Chamber in Tunnel
Scale ⅛ in. to the foot
Under surface of lime stone ledge
Face of sand stone
Stone & Grout
10 X 12
10 X 12
10 X 12
10 X 12
Stone and Grout
Line of excavation of sand stone
Stone and Grout
Lime Rock
Sand stone
Grout
10 X 12
10 X 12
Grout
Sand stone
Cross Section of Tunnel where 20 feet wide
a, a, a. a. Brick work finish on top of Grout.

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bottom, and the space to the sand-rock filled with 8 to 10 inches in depth of stone and then run full of soft cement, so proceeding to the top, finishing the upper layers with brick, the grouting under the bottom of the sills filled between them to their tops, and the whole floor was covered with 4-inch plank, and timber placed over these plank, gained into the posts, to resist any upward pressure from beneath.

To secure perfect faces of sand-rock the width of the tunnel varied greatly, being from 10 to 90 feet, while its height was very constant, being about 16 feet. Whenever more than 20 feet wide, walls were constructed of heavy masonry to support the limestone overhead.

This plan was adopted for the reasons that it cost much less than a solid plug; could be put in in very much less time, and when in was available and, in fact, indispensable for drainage for the leakage while the Government work was in progress, and also to protect it from any damage from springs, as in all cases where any springs were found they were all incased in iron pipes and allowed to flow into the tunnel to prevent washing, and were outside the same.

Eight hundred feet of this lining has been finished in a very thorough manner, and a temporary bulk-head of timber put in about 600 feet from the lower end, in which there is an aperture sufficient for drainage.

The plan for preserving the timber is to put a bulk-head at the mouth of the tunnel, flowing it full of water, with outlet sufficient to remove pressure.

Having this *base* of 800 feet for a bulk-head, the water can be held in perfect safety after the whole work is completed. This bulk-head is the *next* work that, in the opinion of the committee, should be done. In putting this in it is proposed to build of first-class masonry, extended across and connected with the sides of the tunnel in the most substantial manner, through which an iron tube is to be placed on a level with the bottom of the tunnel, provided with an iron gate sufficient to take off all the leakage from work in progress above. This, in case of break at the head of the ledge, will prove of vital importance in stopping the current of water, until such time as the same can again be stopped where it occurs.

The plan of this committee for the work above this bulk-head is as follows: To excavate all the *débris* from the breaks in the bed of the river between the islands, cutting out the sides and bottom, as within the tunnel, to the solid sandstone, then proceed with timber, plank, and filling of stone and grout next the sandstone on each side and on the bottom; this lining to be extended up as near to the head of the ledge on the west side of Nicollet Island as possible, and on the east side until connected with the walls now in at the head of the ledge there; a sewer to be constructed on the bottom, extending up to the Government work, of sufficient size for drainage purposes, then the whole basin between Hennepin and Nicollet Islands, and along the sides of Nicollet Island, to be filled with the best quality of gravel for puddling level with the surface of the limestone, and well secured with riprap. At the head of the ledge and in the bed of the river above all excavations and holes in the sandstone, caused by piers, logs, or any other cause that now exist, to be filled with best gravel and heavily riprapped, forming, in fact, a new bed to the river above the limestone.

It is estimated that the cost of completing the main bulk-head, the lining above the same, the building of the sewer and puddling with gravel up to the head of the ledge, will cost about $90,000, and the puddling and riprap in the bed of the river about $25,000.

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We regard this work as indispensable to the preservation of the fall and of the greatest immediate necessity. We also regard it as nece sarily preliminary to the successful prosecution of the more elabora work undertaken by the Government.

We further represent that the funds provided for this work have be nearly exhausted, and respectfully ask that the Government appropr tion be devoted to the prosecution of the tunnel-lining and puddling t basin, and also the permanent bulk-head.

When all of this work has been completed, and the roll-dams conte plated in the plan of the apron have been built so as to cover the limesto with a sufficient depth of water to prevent the action of frost on the b of the river, we think that the immediate danger to the falls will ha been guarded against.

Having the utmost confidence in the executive ability of Mr. J. Stevens, who has had charge of the work on the apron and on the tu nel, we would respectfully and most earnestly recommend that he continued in charge of the work, under the direction of the Unit States engineer in charge.

Attached, marked "A," find diagram of cross-sections of tunnel.

All of which is respectfully submitted.

S. W. FARNHAM,
R. J. BALDWIN,
S. H. CHUTE,
WILLIAM D. HALE,
Board of Construction.
H. T. WELLS,
O. A. PRAY,
PARIS GIBSON,
M. W. GETCHELL,
Union Committee.
D. MORRISON.
W. D. WASHBURN.
J. S. PILLSBURY.
RICHARD CHUTE.
W. W. EASTMAN.
GEO. A. CAMP.
GEO. H. KEITH.
JAMES A. LOVEJOY.
S. C. GALE.

H 15.

IMPROVING MINNESOTA RIVER.

SAINT PAUL, MINNESOTA, *July*, 1872

COLONEL: I have the honor to submit the following report of ope tions for the improvement of the Minnesota River for the fiscal ye ending June 30, 1872.

On the 1st of September, 1871, the contractor, Mr. S. A. Hooper, co menced the work of removing the bowlders that were left from our la winter's work, from the channel of the river between the mouth Yellow Medicine River and Sacred Heart Reef. The river was at excellent stage for our work, there being not more than eight inches water on some of the reefs we encountered. The work progressed favo

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ably, and on the 22d of September we had removed all of the bowlders, making a straight and wide channel through all the reefs between the mouth of the Yellow Medicine River and Sacred Heart Reef.

On the 23d of September we began work on the Sacred Heart Reef and continued the work at this point until the 12th of October, when the contractor suspended operations to prepare for his winter campaign and until the ice was strong enough for his men to work upon. The bowlders in Sacred Heart Reef were all removed except four, which were left until later in the season.

While the contractor was making his preparations for winter, I made a reconnaissance of the river to a point seven miles below Fort Ridgely, and found a great many bowlders and snags, also overhanging trees on the banks, and logs, which will soon form dangerous obstructions in the river.

On the 11th of December, 1871, we commenced work again on the bowlders remaining at Sacred Heart Reef and continued the work down the river, removing bowlders only, as far as Fort Ridgely. At this place I received a letter from you stating that our appropriation was nearly exhausted, and I stopped work on the 25th of January, 1872.

The year's work has been confined to the removal of bowlders, and the channel of the river, from the mouth of the Yellow Medicine to Fort Ridgely, a distance of seventy miles, is in an excellent condition as regards bowlders. There are a number of snags remaining between Sacred Heart Creek and Fort Ridgely, which we could not remove on account of the small amount of the appropriation left unexpended.

I send herewith a statement showing the number of yards of bowlders removed.

All of which is respectfully submitted.

Your most obedient servant,

EDWIN BELL,
United States Inspector of Work.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A., Rock Island, Illinois.

Statement of bowlder-work on the Minnesota River, to accompany the report of Captain E. Bell, United States inspector.

Date.	Names of localities whence bowlders were removed.	Quantity.		
1871.		*Cubic yards.*	*Cubic feet.*	*Cubic inches.*
Sept. 9	Old Maid's Reef	174	9	181
Sept. 14	Ole Johnson's Reef	141	4	1,488
Sept. 14	Ole Helverson's Reef	32	6	548
Sept. 15	Brownstone House Reef	85	2	392
Sept. 21	La Croix Reef	115	2	1,028
Sept. 23	One mile below Yellow Medicine	12	18	792
Oct. 3	Sacred Heart Reef	214	8	676
Oct. 4	Little Island	38	15	1,140
1872.				
Jan. 10	Working down stream to Beaver Falls	623	16	250
Jan. 25	From Beaver Falls to Fort Ridgely	193	15	876
	Total	1,630	18	459

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H 16.

IMPROVING THE UPPER MISSISSIPPI RIVER.

ROCK ISLAND, ILLINOIS, *July* 1, 1872.

COLONEL: In accordance with your letter of instructions of 29th of April, 1871, appointing me the assistant in local charge of the operations of improving the Upper Mississippi River, with the United States snag-boats and dredges, I have the honor to submit herewith my report from the time of commencing my duties until the close of the fiscal year ended 30th June, 1872.

I repaired to Saint Louis, Missouri, for the purpose of obtaining statistics of the amount and value of the commerce of the Upper Mississippi River, and its relative advantages to the commerce of the country at large, and how far the improvements now being made under your supervision shall tend to subserve the general interest of commerce and navigation. After having carried out my instructions in regard to this matter, so far as to employ a person recommended as one suitable to obtain the desired information, returned to Rock Island in accordance with orders, and reported in person to you for further orders, which were to proceed to La Crosse, Wisconsin, and report in person to Major Benyaurd, United States Engineers, which I did on the 10th day of May, and was immediately placed by that officer in charge of the United States steamers Montana and C. J. Caffrey, with orders to get them in readiness for service as soon as practicable. After a careful inspection of these boats, I found they would require considerable repairs, especially the Caffrey, to put them in condition for effective service. I also found it would be necessary to make a change in the dredging-apparatus of both boats, those used by my predecessor, Colonel Long, not being adapted to a river with so gentle a current as the Upper Mississippi in low water. His would stir up the sand; but in the absence of sufficient current to carry it away, it would settle again in the place from whence it had been raised, and leave the obstruction almost the same as before attempting to remove it.

I succeeded in getting up a dredge or scraper on a plan of my own, which answers very well. It is simple in its construction, and not liable to get out of order. As soon as I ascertained what was required in the way of repairs and alterations to the boats, I employed a number of mechanics and pushed on with the work as rapidly as was necessary to get them ready for service when the river should be in a state to operate to advantage. On the 29th day of May, I received a dispatch from the engineer of the Saint Peter's and Winona Railroad to come to their assistance as soon as possible—the bridge-draw having broken down with a train of cars upon it, and obstructed the passage for boats. I got the Montana under way as soon as possible, and reached Winona on the morning of the 30th, and, after getting ready for heavy lifting, proceeded up to the bridge, raised the "tender," which went down with the bridge-draw, and took it to shore; but the bridge-draw itself could not be raised, it being on the bed of the river, with a train upon it loaded with rock.

[NOTE.—This obstruction was removed by the Winona and Saint Peter's Railroad Company during the winter of 1871–'72.]

After clearing the passage for boats of some of the superstructure, left for La Crosse, where we arrived on the 2d June, and, after removing a dangerous snag which lay just in front of the city, returned to our moorings and resumed our work. On the 27th of June, being nearly

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through with our repairs, proceeded down to Coon Slough, where our presence was required, about twenty miles below La Crosse, and extracted two snags and removed forty-four leaning trees, which overhung and obstructed the channel, returned to La Crosse, June 28, and closed up our business at that place. On the morning of the 29th, both boats being in readiness for the field, left La Crosse for Saint Paul, for the purpose of placing the Caffrey on her field of operations, which was from the head of Lake Pepin to the mouth of the Minnesota River. On our way up, tried the scrapers of both boats, and found them to work to our entire satisfaction. Arrived at Saint Paul the 3d of July, 1871, at 9 a. m. After transacting some business, and giving Captain Hillhouse, of the Caffrey, his orders, left for below, at 3 p. m.

The Caffrey's field of operations covered a distance of, say, ninety miles, and I have reason to believe she did a great deal of good to the navigation over which she worked. The river getting very low during the summer, she was compelled to abandon, at times, that portion of it from the mouth of the Minnesota to the mouth of the Saint Croix, there not being water sufficient for her to operate to advantage, she being of so heavy draught.

The Caffrey is a very old boat, and water-logged, but, her machinery being pretty good, I would beg leave to suggest that a new hull be built for said machinery, which I think can be done at a small cost in comparison with an entire new boat, and a very light draught might thereby be attained, with a proper model, which would be a great desideratum in the prosecution of these improvements, especially in season of low water like the one just past. One great detriment to a successful prosecution of our work has arisen from the frequent passing of boats and rafts, to which, as a matter of course, we were compelled to give place, and another the frequent grounding of small boats of very little power, with their fleets of barges. These boats would come down with from two to five barges in tow. some of which would be loaded to a greater depth than the water on the bars, and, being about as manageable as a raft, would ground and require our assistance a day or more at times to get them off and out of the way, that we might go to work. I do not mention this as a complaint, but chiefly to show that much of our working-time has been consumed in this manner. We have pulled off and set afloat during our season's work thirteen steamboats, some of which were very hard aground, and twenty barges. Our field of operations has been a very extensive one, from the head of the Upper Rapids to the foot of Lake Pepin, a distance of two hundred and fifty miles, and of course in this great distance must cover a vast number of sand-bars, as well as other obstructions, and to keep all these bars in such condition that the large boats could pass them without some little detention, was next to an impossibility; but we have succeeded, as a general thing, in keeping a channel-depth of 3 to 3½ feet during the season of extreme low water by dredging, which is rather a slow process, but I know of none better at present, and I think it should be continued.

After the Caffrey ceased to work above Lake Saint Croix, she continued her labors below, that is, from Prescott to head of Lake Pepin, and kept that part of the river in pretty fair condition, considering the extreme low stage of the water.

Some persons believe in the efficacy of wing-dams to a great extent. I do not, except where the formation is rock or gravel; there they may answer a good purpose, but not on a light, movable soil or sand. Lateral dams might be so placed between Saint Paul and Saint Croix, at

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certain points, as to have a good effect by lessening the width of
river, and thereby increasing its depth proportionately, and, in
opinion, this would be the surest way to attain and secure what is
much desired, water sufficient at all times for the largest boats to Sa
Paul.

I would also beg leave to call your attention to the expediency
furnishing each boat with a pile-driver, that would greatly facilitate
operations in stopping certain sloughs, which carry off a large body
water, and in many places greatly lessen the channel-depth on bars
jacent thereto.

The annexed summary will show the amount of work for the sea
of four months.

Summary of the operations of the Montana for the season of 1871, *f*
months.

Recovered a tender belonging to the Saint Peter's and Winona Railro
which had fallen into the river on the breaking of the draw
the bridge at Winona, and obstructed the passage for boats
13 steamboats pulled off sand-bars and set afloat.
20 barges pulled off sand-bars and set afloat.
289 snags extracted.
33 stumps extracted.
564 leaning trees removed; and, in the prosecution of our work,
4,245 miles, besides keeping a channel-depth of from 3 to 3½ feet on
the bars within our line of operations, a distance of 250 mil

Summary of the C. J. Caffrey, Captain Wm. Hillhouse, for the s
time.

1,600 feet wing-dams.
176 snags extracted.
3,444 scrapes.
92 trees removed.
3,047 miles run.

In accordance with your orders of the 3d November, 1871, I procee
to seek a safe harbor for our boats for the winter, and, after hav
carefully examined and sounded Rockingham Slough, concluded t
that would be a safe place for them, and, as soon as both boats were o
the rapids, took them to the place above named, where I felt assu
they would be safe from ice, and where I left them on the 17th
vember, securely moored, with two men on each boat, to watch and t
care of them. Neither of the boats required docking.

The river at Rock Island broke up on March 27, 1872, and the
passed out without damage to our boats. We immediately went
work to get the boats in readiness to move up to Rock Island. On
6th April, being all ready, got up steam on the Montana, and w
the Caffrey in tow went up to Rock Island and commenced repairs,
soon had the Montana ready for business. The engineers to the Caf
arrived on the 10th of April, and went to work on the Montana.
the 19th put all hands to work on the Caffrey, which boat require
great deal of repairs, and by the last week of June had both boat
condition for service, and, after settling up our business, got ready f

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start up river on the morning of the 1st of July, for our field of operations on the Upper Mississippi River.

All of which is respectfully submitted.

Your most obedient servant,

J. THROCKMORTON,

Assistant Superintendent in local charge of U. S. Improvements Upper Mississippi River.

Colonel J. N. MACOMB,

Corps of Engineers, U. S. A., Engineer in Charge and Gen'l Supt., U. S. Improvements Upper Mississippi River, Rock Islan, Ill.

H 17.

IMPROVING THE ILLINOIS RIVER.

SAINT LOUIS, *July* 29, 1872.

COLONEL: I have the honor to submit the following report of operations for the improvement of the Illinois River, during the fiscal year ended June 30, 1872.

At the date of the last annual report, work was in progress under two contracts; one with F. D. Van Wagenen, under which but a small amount of work remained to be done, the other with James T. Hayden, covering appropriation of $100,000, made at session of 1869–'70, of which $63,729.90 were then unexpended.

The work done by Van Wagenen was the removal of 8,077.6 cubic yards at Peoria Flats, widening the channel to 125 feet, where it had been thought necessary to limit it to 100 feet, on account of supposed want of funds. Two sunken canal-boats were removed from the channel near Peru, Illinois, during July, which being completed the contract was closed. Under the contract with James T. Hayden work has been in progress throughout the year.

During the season of 1871 great delay was experienced on account of extreme low water, for which inadequate provision had been made by the contractor, rendering the work unsatisfactory, and its prosecution annoying to the engineer, and unprofitable to the contractor. As stated in last report, notice had been given to increase the working force, which was done by employing two of the dredges and their equipments, which Van Wagenen had been using on the upper part of the river. These machines did nearly all the work after August 1, clearly establishing the superior fitness of the Osgood dredge over that of Morris & Cummings, for the character and condition of work met in the Illinois River. For the season of 1872 arrangements were made to secure a more energetic prosecution of the work, and since the progress has been satisfactory, partly owing to better management, partly to the favorable stage of water.

A small balance of $678.59 was unexpended at the close of the year, which has since been worked out, and at the date of this report nothing but the final rendering of estimate and settlement remains to close the contract. The amount of work done since July 1 being small, it is included in the following statement of work done, so as to show all that has been accomplished with the means provided.

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The results of the year's operations are —

Wrecking, removing logs, snags, &c.:	
2 wrecks removed at Peru, at cost of	$45
1 wreck removed at Beardstown Bar, at cost of	43
Logs and snags at various points	1 36
Total	2,25
Dams constructed:	
Completion of dam No. 1, Beardstown Bar	$1,59
Construction of dam No. 2, Beardstown Bar	3,67
Construction of dam No. 3, Blue River Bar	2,47
Total	7,74
Dredging:	
8,077.6 cubic yards excavated at Peroia Flats, at 40 cents	$3,23
4,135.0 cubic yards excavated at Toll-Gate Bar, at 24¾ cents	1,02
60,022.1 cubic yards excavated at Beardstown Bar, at 24¾ cents	14,85
36,993.0 cubic yards excavated at Moore's Island Bar, at 24¾ cents	9,15
35,921.0 cubic yards excavated at Naples Bar, at 24¾ cents	8,89
22,596.0 cubic yards excavated at Blue River Bar, at 24¾ cents	5,59
167,744.7 Total dredging during year	42,74
Total wrecking	2,25
Total dams built	7,74
Total of year's work	52,74

Statement of all work done during progress of improvement from Oct 18, 1869, *to July* 18, 1872.

234,427.8 cubic yards excavated prior to July 1, 1871	$85,13
167,744.7 cubic yards excavated since July 1, 1871	42,74
402,172.5 Total dredging	127,88
Total removing wrecks and logs	2,64
2,058 cubic yards dams constructed	8,23
Total work done	138,75

Appropriations.

$85,000, less 1 per cent. reserved	$84,15
100,000, less $10,000 unaccounted for, having never been drawn from the Treasury by you	90,00
Total available	174,15
Paid to contractors	138,75
Expenses and reversions to Treasury	35,39

FUTURE PROGRESS.

No appropriation having been made for the Illinois since 1870. only work provided for at the close of the fiscal year was that possi with the balance of funds then remaining available, which, at the t of writing this report, is expended, and the improvement awaits further action of Congress. The work so done since the close of year is—

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11,471 cubic yards excavated at Blue River, at 24¼ cents	$2,839 07
619 cubic yards material, in dam No. 3, at Blue River, at $4	2,476 00
38 hours' work removing logs, at $12	456 00
Total	5,771 07

The above is included in the general statement already given.

MATERIAL RESULTS OF WORK DONE.

The results mentioned in the last report as having been attained remain as then stated, except that the channel at Kickapoo Creek has been filled by a flood from the creek, a consequence that was to be expected, and which will repeat itself under similar conditions at this and a few other points.

The only practical provision against its occurrence is through annual appropriations for maintenance. That bar being now the worst in the river, much worse than before improvement, its early restoration is desirable, as through it the benefit of much that has been done at other points, where the channel is now in good condition, is practically lost. The expense of such restoration now would be small, but it has not been possible to do anything, the locality being above the limits of the Hayden contract. During the last year four of the worst bars in the river have been removed, all but one of which may reasonably be expected to remain permanently open. The remaining one, Blue River Bar, but awaits the fulfillment of the conditions which have already destroyed the channel at Kickapoo, which will occur at some time, but when it is impossible to predict. The destructive conditions are, as shown by experience, a sudden flood from a creek whose bed is filled with *débris* accumulated during a series of years. The local floods being held in check by a high stage of the river, material accumulates in the lower part of the creek-beds, and remains until a local flood occurs when the river is low, when the tributary stream, overcoming the river-current, projects its waters and material charge entirely across the river, filling any channel that can be located. In such cases the direction of flow is often reversed for miles.

When the river is high the velocity of tributaries is checked before reaching the river, much of the *débris* is deposited on the adjacent low grounds, or in the creek-bed, and that portion reaching the river is held by the superior momentum of the large stream close to the bank from which it enters, and the deposit is made where it interferes little with the navigable channel.

In the cases of local storms of extreme violence, such as have characterized the present season, the destructive action will probably increase as more of the creek-bottoms and hill-sides are cleared and brought into cultivation. These storms being exceptional, it does not appear practicable or necessary to provide against their occurrence; the means which would need to be employed to control these abnormal conditions would be undersirable at other times, moreover would be expensive in construction and maintenance; therefore I think it better to provide for the prompt restoration of a destroyed channel rather than to attempt to maintain it against all contingencies, some of which present experience may not enable us to foresee and provide for. Prompt restoration of destroyed or seriously injured channels is important in consideration of economy, as well as of use, as the newly-formed bars are soft and short in extent, whereas, in time, they will become compact, and by the disturbance of boats aground, and the action of natural forces, more of

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the former channel will be injured, in the end requiring, in some cases, the excavation of new channels for long distances.

The deterioration of the channel in such a season as the present may appear discouraging to the success of the style of improvement adopted, but not really more so than to a slack-water improvement, if we allow a period of years to enter into the consideration; as the deposits must be made in any case, it is only a question of time as to when dredging must be resorted to for their removal. The average cost of maintaining the channel, after completion, I estimate will be $12,000 a year.

The work done the past year being the removal of a few of the worst bars, the benefits are general in prolonging the season of profitable navigation, and in saving the delay, expense, and trouble met heretofore in working over them, rather than in securing a good navigation over a defined distance.

The work that has been done has been on the supposition that an improvement having been commenced, sufficient effort would be made by those interested to secure from Congress the means to complete it speedily, as the plan, to be successful, requires steady and rapid prosecution. The reconciliation of conflicting interests has been carefully studied, and, I think, secured, so far as we have been able to go. It would have been more popular to have done less thorough work, so as to have reached more bars, but the completion of a thorough improvement has been a controlling consideration, and in that light I am content that what has been done shall meet the test that time will give. I am satisfied that the plan pursued is the best for the Illinois, which is to classify the bars, and remove them in the order of their classification, doing thorough work at each locality, up to the full standard of improvement proposed. The estimate for completion of a channel, giving 4 feet draught, from Henry to the mouth, last year was $300,000, for which no later or better data are available; but as work is now suspended, I must add $50,000 to cover cost of restoring channels that are or may be destroyed before work is resumed, making present estimate of completed improvement $350,000. Of this, $150,000 could profitably be expended during the next fiscal year.

Should an appropriation be made, it would be best applied to the removal of the following bars in order, so far as means will allow:

1. Kickapoo Creek Bar, (restoration.)
2. Lancaster Flats.
3. Canton Landing.
4. Grand Island, (West Point Chute.)
5. Sugar Creek Bar.
6. Indian Creek Bar.
7. McKee's Creek Bar.
8. Naples Flats or Garr Island.
9. Bevington Bar.
10. Little Blue River Bar.
11. Buckhorn Bar.
12. Grand Pass.
13. Ottwills.
14. School-House.
15. Apple Creek.
16. French Bar.

Other bars below would require further examination to decide their classification. A full list was given in last report.

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ENGINEERING AND SURVEYS.

The work of the year has been that required to survey, lay out, superintend, and estimate the work done. The season of 1871 being a very sickly one, the party was much reduced in number and ability to work, consequently no observations to obtain a gauge of the river at lowest stage could be made, which is to be regretted, as the water of 1871 was the lowest known.

Soundings for all purposes have been taken mechanically, by means of the machine devised and constructed for the purpose. The depths range from zero to 16 feet, the limit of the present machine. Recent improvements of mechanical details leave the machine well adapted for use upon this river, or others similar; modifications of some of the parts would be necessary to fit it for deeper exploration or use on rocky bottoms. It is well adapted for preliminary surveys, from width covered and speed of movement, though especially designed for surveys where very minute detail is required.

The system of conducting hydrographic operations mechanically involves many new features, which, however, it would be out of place to enter into in this report. A series of maps on scale of $\frac{1}{3000}$ has been constructed to accompany this report, and form a permanent record of what has been done. They show the original soundings and location of improved channels at each place where work has been done. The field-maps (scale $\frac{1}{960}$) will also be returned to your office, but their bulk will render their preservation difficult. The assistants remaining on the work at its close were I. D. McKown and R. A. Brown; their performance of duties has always been satisfactory. I have no information as to revenue or commerce during the past year.

Very respectfully, your obedient servant,

ROBT. E. McMATH,
Civil Engineer Assistant.

Colonel J. N. MACOMB,
Rock Island, Illinois.

H 18.

IMPROVING THE DES MOINES RAPIDS.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, August 1, 1872.

COLONEL: I have the honor to submit to you the following report of the operations performed on the improvement of the Des Moines Rapids for the fiscal year ended June 30, 1872:

LOCK-WORK.

As per last annual report it will be seen that work was being performed under contract with the following parties:

At lower lock, Mr. Ephraim Owen; at middle lock, Mr. Willard Johnson; delivery of stone, Messrs. Wells, Timberman & Co.; and for delivery of cement, Mr. James Clark; section-work, Messrs. Dull & Williams.

First: Lower lock.—Every means were taken to push the work forward as rapidly as possible, on account of the favorable state of the

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summer weather, as there had never been so favorable a season for contract-work since the improvements were started.

The stage of water in the river, the temperature of the weather, and state of the laboring men, were such as to be not only to the advantage of the contractors, but to enable the performance of a better class of work. The amount of money allotted, however, to this portion of the improvements being small and inadequate for the completion of any particular work, great care was necessarily required in ordering certain items forward more rapidly than others, in order that safety from winter and river might be guaranteed.

As soon as Mr. Owen completed his contract, I had a force employed for a few days in laying some coping, and in spreading manure and sand on top of the unprotected walls, and as soon as this was done the water was let into the coffer-dam to relieve the pressure. There have been 12 or 15 feet of water in the pit ever since.

At the present time every portion of this lock is in a splendid state of preservation. Work ceased October 5, 1871, from expenditure of funds.

Second: Middle lock.—Work stopped on this lock September 9, 1871, on account of want of funds.

As with the lower lock, so with this, precautions were taken to insure safety. There are now 8 feet of water in the lock-pit. Work can be resumed there in one day's notice, machinery, &c., being in position.

Third: Stone.—The contractors, Messrs. Wells, Timberman & Co., furnished stone from Senora quarry, Illinois, 6 miles from Keokuk.

Every care was taken in the selection of proper stone, and the measurement, &c., was done under my own inspection.

Fourth: Cement.—Mr. James Clark, of Utica, Illinois, furnished and delivered at the lime-houses, at each lock under his contract, 6,312 casks hydraulic cement, (300 lbs. per cask;) 508 casks hydraulic cement, in sacks. (150 lbs. per sack.) This cement is of a very superior quality. In laying large stones, such as coping, miter-sills, and hollow quoin-stones, the majority of hydraulic cements set too rapidly, and therefore prevent an accurate laying of the walls. The Utica cement furnished by this party does not harden so quickly as the Louisville and other cements, hence its superiority for this class of work.

The cast-iron for ventilators was furnished by M. W. Westcott, of Keokuk, Iowa, having been purchased in open market. The total number of pounds furnished and delivered was 44,456½. Twenty-seven thousand four hundred and seventy-one pounds wrought iron were bought of Brownell Bros., and Rothert Bros., of Keokuk. This iron was used as fastening-rods for gates, and also for clamps and bolts for coping.

Fifth: Section-work.—With regard to this portion of the improvement I have the honor to report that during the fiscal year ended June 30, 1872, there has been but one month's work performed by the Government upon it, namely, during the month of July, 1871.

In anticipation of the stoppage of operations upon this work, (on account of the exhaustion of the appropriation,) orders were given about the beginning of the month to the contractors to set pumps at work at the lower end of the canal, near the point of junction with the outside bank of the coffer-dam for the lower lock, so that the leak through the bank at that point (caused by the manner in which the coffer-dam and bank were obliged to be connected) might be thoroughly stopped, and the defect entirely remedied. In addition to the leak at the lower end of the canal-prism above mentioned, there appeared three others, two through the bank, that washed out some of the material of which the

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bank was composed, and one through crevices in the bed-rock of the river. The two through the bank were thoroughly stopped. The one through the bed-rock, not doing any damage to the work during construction, was allowed to remain untouched, in anticipation of stopping it during the next contract.

On the 19th of July, according to orders from this office, the contractors, Messrs. Dull & Williams, began to deposit all the earth excavation upon the outside bank of the lower lock, and continued so to do until noon of August 3, when peremptory orders were given to stop all work on Government account on the section-work.

On the 21st of July, 1871, orders were issued that the work must stop on or about the 31st of July, and the contractors should govern themselves accordingly. In view of this fact, instructions were given to have the whole of the inside of the bank heavily protected with loose stone; not to extend the building of the walls, but to raise them as high as possible where built; to protect all exposed portions of the work on the outside, and place everything in as good condition as possible to withstand the effects of the winter, frosts and spring floods until operations should be resumed next year. On July 27th, the water in the lower pit having been sufficiently pumped out, a force of as many men as could work was placed in the leak to repair it, and by the morning of the 31st it was stopped, and the bank thoroughly puddled and built up over it in a substantial manner, no fears being entertained of its ever breaking out again.

As the latter part of the month of July had been devoted to placing the work in a condition to remain idle for some time to come, or until a new appropriation should be made by Congress, and as the original design had been as thoroughly carried out as practicable, and as all work on Government account had stopped July 31, 1871, of course there was a cessation of active operations at that time.

During the month of August a system of test-levels and a corroborative survey of triangulations and hydrographic observations were instituted, and carried on the next three or four months, with very satisfactory results, both in regard to their intrinsic value and as a comparison and confirmation of the accuracy of the former surveys.

From the time of the closing of the last contract up to June 30, 1872, no work at all has been done upon the section-work, owing to the exhaustion of the appropriation.

The winter of 1871–'72, however, was not a very hard one, and the spring floods of 1872 were very light; consequently, in consideration of the efforts made to preserve the work, it is now in as good condition as it was in August, 1871, and work could be resumed upon a week's notice. During these months a close watch has been daily kept of the whole work, and the bank has not washed a particle, nor has a stone slipped from its position.

The substantial character of the work is due, in a great measure, to the thorough manner in which the contractors, Messrs. Dull & Williams, have carried out instructions from this office, and their willing acquiescence and uniform courtesy, together with the large amount of capital and machinery with which they have prosecuted their contract. Their willingness to obey orders and execute their contract, at whatever cost, have enabled them to accomplish more than any other firm on the work; and I would respectfully recommend them to the favorable consideration of the Department as reliable, energetic, and efficient contractors.

After closing the work, the engineer force was employed in running test-levels for the bench-marks of the whole line.

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Five distinct lines of leads were run by different parties, and the differences checked off by myself. After a comparison of these with four previous sets, made in previous years, and on which was based the grade of the canal, (as was also the reference of the tops of the miter-sills of the locks,) I decided that no change was necessary, as they all were almost coincident. These lines were run with the utmost care, and most of the time of the work I was present myself, either at the rod or with the instrument.

During the winter nothing unusual occurred to report, the engineer force being engaged in perfecting records, making drawings, &c.

Several reports were required and forwarded, and must now be in the Department.

On June 10, 1872, the President approved the river and harbor appropriation bill, on which was an item of $400,000 for this work.

Having received notice (unofficially) that this would be the probable amount allowed, I had already prepared a project of operations, and, on receiving the proper orders, immediately forwarded it to you. In this I recommended that certain portions should be advertised, and certain others should be given to the former contractors by extension. This was disapproved by the Department for reasons given in letter dated Washington, D. C., June 26, 1872, and these portions ordered to be advertised.

During the year ending June 30, 1873, if no appropriations are made during the next session of Congress, I propose to finish the lower lock, with the exception of the gates and machinery, to well forward the middle lock, while the balance of the appropriation will be put into the section-work to be expended in the excavation of earth and stone, the building of exterior riprap wall, and the raising of the entire bank to the proper height.

The amount expended to June 30, 1872, the end of the fiscal year, is $288,843.41, and as no reason exists at present for changing my last estimate, there will be required, as per estimate, $1,723,481.19.

Amount on hand at commencement of fiscal year	$400,000 00
Amount expended during same period	288,843 41
And, by authority, toward close of fiscal year ended June 30, 1871	110,944 06
	399,787 47
Leaving	212 53
Amount appropriated by act of June 10, 1872	$400,000 00
Amount available for fiscal year ending July 1, 1873	400,212 53
Balance required over previous appropriations to complete the work	1,323,481 19

Of which the sum of $1,000,000 could be advantageously used during the fiscal year ending June 30, 1874, but I would strongly recommend the passage of an appropriation of, say, $500,000 during the next session of Congress, to be made immediately available, and that the balance of $823,481.19 be appropriated by the first session of the next Congress. By this means the work would be in continual progress during the entire working season of 1873.

In case of continual small appropriations, there is no doubt that it will take several years to complete this work, and the expense to the Government will be largely increased on account of the evident damages which will occur to the work from its incomplete state, arising from leaks in the bank, slides from unprotected portions, and other points which have been mentioned in previous reports.

In case that Congress should see fit to make an early and large

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appropriation during the coming session, equal to the balance of my estimate at present prices, (there is, of course, a possibility of a change in the same,) I have no doubt that the work could be placed in a fit state for boats to pass, and navigation kept up throughout the year, excepting when the canal might be frozen. On account of loss of time and change in prices, I am in doubt as to the sum I have given in my estimates being sufficient, but no alteration can be made until the forthcoming letting, consequently use the same figures as furnished in my report to you dated November 10, 1871.

In closing I wish to extend my thanks to my corps of assistants, who have worked without exception to forward the work in good style, and would especially mention Messrs. Griffith, Worrall, Blaisdell, (now with General Raynolds,) Bayless, and Middleton, civil engineers, and Messrs. Carpenter and Costello, inspectors, as also Mr. O. S. Willey, civil engineer and draughtsman.

Appended herewith is a statement marked "A" of all work done excepting cement and materials purchased in "open market") upon the improvement of the Des Moines Rapids of the Mississippi River, during the fiscal year ending June 30, 1872.

All of which is respectfully submitted by your most obedient servant,

A. H. BURNHAM,
Captain of Engineers, United States Army, in local charge Des Moines Rapids Improvement.

Colonel J. N. MACOMB,
Corps of Engineers, United States Army, Rock Island, Illinois.

H 19.

IMPROVING THE DES MOINES RAPIDS.

Proceedings of a board of engineers convened at Keokuk, Iowa, by virtue of the following order:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 27, 1871.

COLONEL: The board of engineers constituted by Special Orders No. 8, Headquarters Corps of Engineers, January 19, 1871, will reconvene at Keokuk, Iowa, on the 8th of November next, or as soon thereafter as practicable.

The board will inspect the Des Moines Rapids improvement, and report fully its condition and the progress made in its construction, together with the additional work that will be done under existing contracts.

The board will further report what remains to complete the improvement, including the Montrose Channel and the channel below the lower lock of the canal, and will submit an estimate, in detail, for the completion of the improvement of the rapids, accompanying the estimate with such explanatory remarks as may be required to show the causes of difference that may be found in the amounts of estimates heretofore submitted, and those submitted by them.

Colonel Macomb will detail such assistants as the board may need, from among the officers, or others under his direction.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Colonel J. N. MACOMB,
Corps of Engineers, Rock Island City, Illinois.

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KEOKUK, IOWA, 10 o'clock a. m.,
December 2, 1871.

The board met pursuant to the foregoing order. Present: Colonel J. N. Macomb, Corps of Engineers, United States Army; Brevet Major-General J. H. Wilson, United States civil engineer.

The board on meeting appointed Captain A. H. Burnham, Corps of Engineers, United States Army, recorder, and proceeded to consider—

First. The subject of the Rock Island Rapids improvement, and came to the following determination:

To respectfully call the attention of the Chief of Engineers to the last annual report on this work, rendered by Brevet Major E. F. Hoffmann, civil engineer assistant, through Colonel J. N. Macomb, Corps of Engineers, United States Army, engineer in charge of the work; also to recommend that $200,000 be appropriated during the present session of Congress, and that this be done immediately. It is thought by the board that this amount of $200,000 will complete the improvement and open the Rock Island Rapids for navigation at all stages of water. In explanation, it is to be stated that the recent surveys, in minute detail, conducted by the party under the immediate supervision of Major E. F. Hoffmann, have shown the existence of several patches of rock not heretofore considered, which constitute obstructions that must be removed, thus increasing the amount of the estimates hitherto submitted. The entire sum asked for can be economically expended during the coming season.

Second. The improvement of the Illinois River.

Below is given the report of Mr. Robert E. McMath, civil engineer assistant, under whose immediate charge the work has been for the past two years, and in whose opinion the board fully coincides. The large sums proposed for contingencies, is caused by the peculiar situation and character of the work necessary.

The board believes that $306,226.60 will complete the work, as stated in Mr. McMath's report, and that $150,000 thereof can be advantageously used during the coming season. It consequently recommends the appropriation of that amount.

KEOKUK, IOWA, *December* 2, 1871.

CAPTAIN: The work for the improvement of the Illinois River at the close of the last fiscal year, June 30, 1871, was complete for the distance of fifty-two miles, affording a navigable depth of 5 feet from the State lock and dam, at Henry, to Peoria, a distance of thirty-seven miles, and a depth of 4 feet from Peoria to Kingston, a further distance of fifteen miles.

As this work was done with a view of preparing a bottom for a 7-foot navigation after the construction of a proposed lock and dam at Copperas Creek, the depth now available diminishes toward the lower end. The construction of the proposed system of locks and dams being yet uncertain, the work done below Kingston has been prosecuted in the interest of present navigation, and, so far as executed, affords a minimum depth of 2½ feet from Kingston to Beardstown, a distance of seventy-five miles. Consequently, the result of the work up to the above date is a completed improvement of fifty-two miles, and a partially completed improvement of seventy-five miles; total length of river improved, one hundred and twenty-seven miles, all of which is in good condition at the date of this report.

The work done upon the seventy-five miles has been confined to the localities where the depth was less than 2½ feet, leaving all bars having a greater depth untouched; but wherever work has been done, the bars were removed to the depth of 4 feet, according to the plan adopted for the complete improvement. To secure the greater immediate benefit from the improvement during its progress, it has been thought best to classify the bars according to their character as obstructions, and to remove them in the order of classification. The means now available are sufficient to extend the 2½ feet improvement thirty-seven miles, and bring it to a point where the navigation of the Illinois depends, in a great measure, upon the stage of water in the Mississippi.

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The estimate for the completion of the improvement up to a standard of 4 feet depth is:

	Cubic yards.
Dredging	1,305,040
Dams	15,012
Deduct for work now under contract:	
Dredging	334,904
Dams	3,137
Leaving to be provided for:	
Dredging	970,136
Dams	11,875

The estimated cost is:	
970,136 cubic yards of dredging, at 25 cents	$242,534 00
11,875 cubic yards of dams, at $2	23,750 00
Engineering and contingencies	39,942 60
To be appropriated	306,226 60

If the means are provided the work in question can be completed in two years, and the estimates are based upon its vigorous prosecution. The cost would be materially increased if the work is delayed. The amount that can be profitably expended during the coming year is $150,000; by the expenditure of that amount, a depth of 3 feet will be secured for navigation throughout the river.

Experience thus far justifies the opinion that the improvement has a reasonable degree of permanence in its character, and after completion can be maintained in full efficiency by the annual appropriation of $15,000.

Very respectfully,

R. E. McMATH,
Civil Engineer.

Captain A. H. BURNHAM,
Corps of Engineers, United States Army, Recorder of Board of Engineers.

Third. **Improvement of Des Moines Rapids of the Mississippi River.**

The board, after due investigation, find the amount of work completed and yet to be done, as follows:

I. At the lower lock—expended		$319,893 00
	required	54,961 00
Total		374,854 00
Work completed, 85 per cent. of the whole.		
To be done, 15 per cent. of the whole.		
II. At the middle lock—expended		$61,793 89
	required	145,248 00
Total		207,041 89
Work completed, 29 per cent. of the whole.		
Uncompleted, 71 per cent of the whole.		
III. At the guard-lock—expended		
	required	$246,272 00
Total		246,272 00
Work completed, 8 per cent.		
Work uncompleted, 92 per cent.		

The board have only enumerated the percentage of work done and to be done on the locks, as exact amounts would only increase the extent of this report without affording definite information to the Department.

The foregoing estimates do not include the cost of the gates, and the necessary cement and wrought iron.

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Timber for the gates has been purchased, also the cast-iron heel-posts. The labor and materials for putting them together is estimated at *$3,000 for each gate, or for all the gates of the three locks, say $40,000, including contingencies.

Cement:	
Delivered at lower and middle locks	36 per cent.
Required at lower, middle, and guard locks	64 per cent.
Wrought iron:	
Delivered	59 per cent.
Required	41 per cent.
For stone:	
Expended	$312,789 12
Required	295,809 00
Total	608,598 12

At lower lock.

Stone delivered	95 per cent.
Stone required	5 per cent.

At middle lock.

It is impossible to give an accurate estimate of the different kinds of stone on hand, as to quality, &c., owing to the effect of frost on the unseasoned stone not yet dressed; it is believed, however, that nearly all is furnished.

Guard-lock.

Stone delivered	19 per cent.
Stone required	81 per cent.

These items are as closely made up as possible, but those referring to lock-work may vary hereafter, as it is not practicable to determine the exact amount of excavation necessary to obtain the proper solidity of foundation for the lock-walls. This has been exemplified during the past summer at the middle lock, where it was found necessary to excavate for that portion of the masonry and other portions of the work commenced, from 18 to 27 inches below lock-bottom. This was due to the lack of homogeneity in the upper strata of the rock on which the lock is placed.

With reference to the stone for lock masonry it must be said that the peculiarity of the magnesian limestone found on the Mississippi River renders it difficult to classify it exactly till it has been partially dressed; hence, in some cases, stone thought at one time to be fit for face-work has been subsequently condemned or thrown into "backing," and *vice versa*. No care or diligence can prevent this, as the appearance of the stone fresh from the quarry is often very deceptive.

It is difficult to estimate the section work exactly; but the following tabulated statement of the work done and yet to be done has been prepared from the records of the office, and is believed to be as accurate as it can be made till the work is completed:

Cubic yards of earth, (at 91⅔ per cent.)	683,462.5
Cubic yards of rock, (at 97⅞ per cent.)	356,988.1
Cubic yards of embankment, (at 56$\frac{3}{10}$ per cent)	40,330
Cubic yards of puddling, (at 54⅛ per cent.)	4,853.7
Cubic yards of lining, (at 100 per cent.)	2,669.1

*Information has been sought, but not obtained, from several parties.—A. H. B.

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Cubic yards of stone to be borrowed, (at 47½ per cent.)	71,499,8
Cubic yards of riprap wall, (at 36 per cent.)	52,107.2
Cubic yards of vertical wall, (at 12 per cent.)	200
Miles of railroad, (at 100 per cent.)	1.44
Rods of public road, (at 40¾ per cent.)	377¾

The above figures represent amount of work actually done on section-work.

The figures below represent amount of work yet to be done on section-work:

Cubic yards of earth, (at 8⅜ per cent.)	64,750
Cubic yards of rock, (at 2⅜ per cent.)	9,580
Cubic yards of embankment, (at 43$\frac{1}{10}$ per cent.)	30,560
Cubic yards of puddling, (at 45¾ per cent.)	4,100
Cubic yards of stone to be borrowed, (at 52¼ per cent.)	80,000
Cubic yards of riprap wall, (at 64 per cent.)	92,750
Cubic yards of vertical wall, (at 88 per cent.)	1,500
Rods of public road, (at 59⅓ per cent.)	550

The amount of money actually paid out for work done on the section-work, exclusive of engineering expenses and land damages, is $1,431,629.62, or 78⅔ per cent. of the amount required.

The amount of money required to complete section-work, based on last contract prices, is $388,469, or 21⅓ per cent.

The board visited the canal, and found that the work upon its various parts had been conducted with skill, energy, and fidelity, as well as in accordance with the plans and directions of the engineer in charge.

The quality of the materials furnished seems to be fully up to the standard required by the contracts covering the same. The action of the frost has resulted in splitting some of the stone which had not been sufficiently freed from quarry water before the cold weather came on, but what loss will be incurred by the Government from this cause cannot be precisely stated till the lock-walls shall have been completed. It is not believed that the aggregate quantities of stone required will be seriously changed by this cause.

The board finds that this work has been conducted strictly in accordance with the laws of Congress having reference to contracts, and quite as economically as is practicable under the system of partial appropriations. Major Burnham, the officer in local charge, has carried out ably and faithfully the instructions received from time to time from the superior authorities.

On the subject of the Montrose Channel, no reason is seen for changing the original estimate, which is for 37,054 cubic yards at $7=$259,378.

The channel below the lower lock has not been heretofore looked upon as a matter of great importance, as in the original project it was supposed that all boats which could reach Keokuk, ascending the river, could at all times enter the mouth of the canal by pursuing the shortest line from the channel; but in view of future improvements of the river below Keokuk, and the construction of the railroad bridge, projected and built since the location and commencement of the lock, which renders it necessary to take a line for the channel passing between the draw-pier and the Iowa side of the draw, thus increasing the length and depth of the excavation and rendering a great part of it absolutely necessary to meet the ordinary conditions of the present low-water navigation, the following estimates have been prepared for channel of four, five, or six feet in depth.

Rating earth excavation at 30 cents a cubic yard, and rock excavation at $8 a cubic yard, including expense of constructing coffer-dams—

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For a channel four feet deep:	
4,000 cubic yards of earth at 30 cents	$1,200 00
11,129.7 cubic yards rock excavation, at $8	89,037 60
10 per cent. for contingencies	9,023 76
	99,261 36
For a channel five feet deep:	
4,000 cubic yards earth, at 30 cents	$1,200 00
18,574.7 cubic yards rock, at $8	148,597 60
10 per cent. for contingencies	14,979 76
	164,777 36
For a channel six feet deep:	
4,000 cubic yards earth, at 30 cents	$1,200 00
26,019.7 cubic yards rock, at $8	208,157 60
10 per cent. for contingencies	20,935 76
	230,293 36

The most important reasons for an increase in the amount of the appropriation asked for are:

First. It was originally considered that the entire amount of "slope" and "riprap" wall-stone would be furnished by the excavation from the prism of the canal, whereas it has been found that a large amount of this must be "borrowed" or bought, and both processes have been adopted during the past season and must be in the next. This arises from the fact that a large amount of rock, when excavated, is found to be entirely unfit for building purposes; some is so worthless as to crumble from a slight pressure of the fingers, or if stronger, from the effects of the first frost. Other portions when blasted give such an amount of small fragments as to be entirely useless for purposes of protection.

In conclusion the board respectfully calls the attention of the Chief of Engineers to the reports of Captain A. H. Burnham, Corps of Engineers, United States Army, in local charge of this work, and to a condensed estimate for the completion of the work; also to letters and reports now on file in the Engineer Department from the various officers in charge of these works at different times, concerning the increased cost of labor and materials, if partial appropriations only are made. The members of the board see no reason for changing their opinion on this subject, and would state that in partial appropriations lies the great cause for increased cost over the original estimates; and further, it may not be amiss to say that it is impossible for any one to foresee what may be the prices, in the accepted bids, for doing the work or furnishing materials under the contract system, and hence while the board has taken all ordinary precautions to make accurate estimates, it does not wish to be understood as giving figures herein for anything else than the closest approximations attainable in the case.

SUMMARY.

For completing Rock Island Rapids	$200,000 00
For completing Illinois River improvement	306,226 60
For completing Des Moines rapids improvement:	
1. Section-work	$398,469 00
2. Lower lock	54,961 00
3. Middle lock	145,248 00

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4. Guard lock	$246,272 00
5. Stone	295,809 00
6. Montrose Channel	259,378 00
7. Channel below lower lock if of only 4 feet depth	99,261 36
Add for contingencies on Nos. 2, 3, 4, and 5, 10 per cent.	74,229 00
For lock-gates, say*	40,000 00
Total	1,560,627 36
Additional for a channel of 5 feet in depth below lower lock	65,516 00
	1,669,143 36
Additional for a channel of 6 feet in depth below lower lock	65,516 00
Grand total for the improvement of Des Moines Rapids	1,734,659 36

All of which is respectfully submitted.

J. N. MACOMB,
Colonel of Engineers, U. S. A., President of Board.
J. H. WILSON,
United States Civil Engineers.
A. H. BURNHAM,
Captain Engineers, U. S. A., Recorder.

H 20.

IMPROVING THE DES MOINES RAPIDS.

ROCK ISLAND, ILLINOIS, *March* 7, 1872.

GENERAL: In accordance with the requirements of your letter of the 7th ultimo, a careful examination of the records at Keokuk, touching the estimates which were presented for completing the United States improvement at Des Moines Rapids of the Mississippi River, has been made, upon which is based the within explanatory report which is signed by General Wilson and myself, and seems to justify the recent rather than the former estimates, and to show the causes of the difference to which our attention was called.

All of which is respectfully submitted by your most obedient servant,

J. N. MACOMB,
Colonel of Engineers, United States Army, Engineer in Charge, and General Superintendent United States Improvement Des Moines R.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. Army, Washington, D. C.

NEW YORK, *February* 28, 1872.

GENERAL: In answer to your letter of February 7, 1872, we have the honor to submit the following statement, the data for which was compiled from the office-records by Major Burnham:

1st. *Section-work.*—Your letter states: "Canal-prism, total of earth and rock excavation, original estimate, (board of engineers, July 20, 1867,) 448,348 cubic yards."

* Information has been sought, but not obtained, from several parties.

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This statement does not agree with the records of the original estimate, retained in the office at Keokuk. It should be as follows:

	Cubic yards.
Excavation of rock	200,000
Excavation of rock	300,000
Embankment, (excess of excavation)	67,400
Total	567,400

Again, as your letter does not state the fact, we presume it has been overlooked, but after this work was started in November, 1867, a revised estimate from actual cross-sections was taken and found to differ materially from the original estimate handed in by the board of engineers of July 20, 1867, and as the revised estimate was taken more carefully, and every endeavor made to have it accurate, General Wilson being then in charge, it was adopted as the original estimate for office purposes. From that estimate we find:

	Cubic yards.
Excavation of rock	216,326
Excavation of earth	599,998
Embankment, (excess of excavation)	229,050
Total	1,045,374

which, as you will perceive, shows considerable difference from the original, or what should be more properly called the "estimate based on preliminary surveys."

Having now stated what we started from, namely, the revised estimate, a copy of which, dated February 29, 1868, is among the records of General Wilson's papers, we will explain another difference.

Your letter states, "Exhibit of January, 1872, shows excavation as 1,119,780 cubic yards." This, we presume, is made up as follows:

	Cubic yards.
Earth excavation, (finished)	688,462
Earth excavation, (unfinished)	64,750
Rock excavation, (finished)	356,988
Rock excavation, (unfinished)	9,580
Total	1,119,780

From the above showing, the difference deducted, as per your letter, is 671,432 cubic yards. It should have been, as per first statement, 552,380 cubic yards. But take the revised estimate of February 29, 1868, and it will be seen that the original estimate, instead of being 567,400 cubic yards, was 1,045,374 cubic yards. This materially lessens the difference from the original estimate, and it now becomes 74,406 cubic yards of increase over original estimate. To explain that, we would call your attention to various reports made from the office at Keokuk, particularly Major Burnham's last yearly report, and also report dated 10th May, 1871, (monthly,) in which the subject of increase of material and of cost with regard to this work is discussed in full. The reason, however, for the great increase of excavation over the revised original estimate is accounted for more fully from the fact that, first, General Wilson in the latter part of the year 1868 ordered the grade of the canal to be changed from a perfect level to an incline of 1¾ inches to the mile. This grade in a distance of five miles, and with the immense width of prism of 300 feet, gave considerable of an increase of material to be excavated, especially through Sandusky, Rickey's Distillery, and the middle lock pits, both of rock and earth, but through the earth excavation above

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the middle lock, particularly just below where Price's Creek debouches into the canal. During the progress of the work it was found that the rock bed laid some four feet below the theoretical grade of the canal, and that if we excavated that earth it would aid in the construction of the embankment and also provide a pool or reservoir for the deposit of the silt from Price's Creek. This was approved by General Wilson, then in charge.

Again, during the progress of the work it was found that rock suitable for the building of the riprap-wall obtained from excavation was running short; it was advisable, if possible, to obtain this rock from the prism of the canal, the only way to do so was to go below the theoretical bottom, or take it from the sides; as by the first plan of building the canal it was proposed to leave the excavation through rock only 250 feet wide. We had a berm bank on the west side of the canal of 50 feet in width for the whole length of excavation below the middle lock, and for a large part of the excavation above the middle lock, which it was found could be made available without going outside of the canal for said material; consequently instructions were given by Major Burnham to have that berm excavated and the material used for building wall, and an item of agreement covering this point was inserted in the last contract with Messrs. Dull & Williams, the parties who did the last work on the canal. The above explains fully the difference of 74,406 cubic yards in the amount of excavation.

2d. In regard to stone for riprap-walls, (total of excavated and loose original estimate, board of engineers, July 20, 1867,) your letter of February 7, 1872, makes 192,000 cubic yards. The original estimate from which the above was taken makes it 343,000 cubic yards. There seems to be an error here.

The revised original estimate hereinbefore mentioned, of February 29, 1868, makes the amount of riprap borrowed (or loose) and excavated, 324,310 cubic yards, which is not quite as much as was estimated in the "estimate on preliminary surveys." Again, referring to your letter we find that the exhibit for January, 1872, is as follows:

	Cubic yards.
Stone to be borrowed, (finished work)	71,499
Stone to be borrowed, (unfinished work)	80,000
Riprap-wall, (finished)	52,107
Riprap-wall, (unfinished)	92,750
Total	296,356

which is a decrease instead of an increase from the original estimate, both of the "estimate on preliminary surveys" and of the revised estimate of February 29, 1868; consequently that inquiry is sufficiently answered by the mere statement of the fact.

It may not be amiss to state why the stone for riprap-wall turns out less upon construction than the estimate, and it is found in the fact that General Wilson changed the slopes of the inside of the bank from 1½ feet upon 1 foot to 1¼ feet upon 1 foot, thereby reducing the hypothenuse of the angle of slope and lessening the number of yards required.

3d. *Locks.*—The revised estimate of General Wilson, December, 1868, was $1,090,000, and we respectfully call the attention of the Chief of Engineers to the letter of General Wilson, dated December 3, 1868, in which the cost of the three locks is fixed at the above price, viz, $1,090,000, and also to the remarks made therein concerning the uncertainty of the contract-prices. At that time it was anticipated that the prices of Tobie & Co. for stone, and E. Owen for labor in construction

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of lower locks, would determine the final cost of the construction of the three locks, and also the delivery of all stone required.

In the first place, it should be remembered that the plans of the locks have been considerably modified in details, fixtures, and cost, all of which tend to materially increase their first cost, but to lessen the cost of maintenance.

The prices for labor in construction of middle guard-locks have been based upon prices at lower lock.

The prices for stone in estimate of January, 1872, were based upon prices of last contractors, viz, Messrs. Wells, Timberman & Co. Mr. Tobie's price in 1868 for stone was as follows: face-stone, $6.90; backing, $4.25; and these were the prices upon which General Wilson based his estimate.

According to the original estimates made by General Wilson in 1868, and prices of Mr. Tobie (upon which amounts of money were estimated) were as follows:

9,903 cubic yards face-stone, at $6.90	$68,330 70
17,178 cubic yards backing, at $4.25	73,006 50
18,230 cubic yards (vertical wall) rubble-stone, for $4.25	77,477 50
1,870 cubic yards (slope wall) rubble-stone, for $2.50	4,675 00
Total	223,489 70

to actual amount of stone then required to finish three locks. Mr. Tobie having failed to furnish the stone at above prices, surrendered his contract in 1869, and a reletting was required.

According to the subsequent prices the quantities amount as follows, after deducting the quantities furnished by Mr. Tobie, viz:

334 cubic yards face-stone;
50 cubic yards backing;
293 cubic yards vertical-wall stone;
40 cubic yards slope-wall stone;

there remained to be furnished, (and at the subsequent and present contract prices the result obtained is as follows:)

9,569 cubic yards face-stone, at $16.50	$157,[illegible] 70
17,128 cubic yards backing-stone, at $9.50	162,716 00
17,937 cubic yards (vertical-wall) stone, at $9.50	170,401 50
1,830 cubic yards (slope-wall) stone, at $5	9,150 00
	500,156 00
Deduct original estimated cost	223,489 70
	276,666 30

over and above original estimated cost.

The above figures must be increased at least 75 per cent. on account of increased amount of wing and connecting walls, which could not be constructed out of stone excavated from the prism of the canal, as was intended. This gives an actual amount in cost of entire amount of stone required to fully complete the three locks, $484,166.02 over and above the original estimated cost for same.

With regard to the construction of the three locks, in addition to the increase of quantities, washing away of materials by floods, and consequent destruction of one wall at lower lock, the attention of the Chief of Engineers is also called to another portion of General Wilson's letter of December 3, 1868, to the Department, wherein he says:

> That with partial appropriations, &c., the entire work *must* be increased *very materially* in cost and be greatly delayed in its final completion, &c., &c.

This prediction of General Wilson's has been fully verified. The

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prices of important items have been very materially increased. The estimate of January, 1872, for completion of the locks was based upon figures of last contracts, to which it is safe to say that an increase of at least 10 per cent. may be expected, for the simple reason that with each reletting the contract prices increase in about that proportion. This item of 10 per cent. will cover the $74,229 enumerated in your letter.

In conclusion we may call attention to the fact that the estimate of January, 1872, was compared with the estimate of July 20, 1867, instead of the revised estimate of General Wilson, of December 3, 1868.

In the first case the estimate was $763,471; in the revised estimate of December 3, 1868, $1,090,000; difference, $326,529. Therefore, after adding to this sum, viz, $326,529, the sum previously determined upon with regard to stone, viz, $484,166.02, gives $810,695.02, as an amount actually in favor of the January, 1872, estimate made, provided the amount of original estimate is compared with the January estimate.

This estimate was made after several years of observation and practical experience on this particular work, and was determined upon after noting the delays in appropriations, and in each reletting, and actual cost of doing each item of work, whereas the original estimate was made without any actual knowledge of it.

Trusting that the foregoing statement, together with the previous reports, may enable you to properly understand the particular difficulties of this case,

We are, very respectfully, your obedient servants,

J. N. MACOMB,
Colonel Engineers U. S. A., Engineer in charge, and General Superintendent Des Moines Rapids Improvement.

J. H. WILSON,
United States Civil Engineer.

Brigadier-General HUMPHREYS,
Chief of Engineers, Washington, D. C.

H 21.

IMPROVING THE ROCK ISLAND RAPIDS.

UNITED STATES ENGINEER OFFICE,
Rock Island, Illinois, August 15, 1872.

COLONEL: I have the honor to submit my annual report of operations for the improvement of the Rock Island Rapids during the fiscal year ending June 30, 1872.

The work of excavation, under the contract with Mr. J. J. Dull, was commenced on the 26th of July, 1871, and, with the exception of the interval between November 19, 1871, and April 1, 1872, during which time work was inexpedient, owing to the ice and prevalent high water, has been pushed forward with great energy up to the present date. The rock has been removed by use of coffer-dams and by chisel and dredge.

I. The contractor began operations at Smith's Chain. Your predecessor intended improving the old channel at this chain, but from a more extended survey by soundings, and a comparison of the respective quantities of rock to be excavated, you decided in favor of a new cut, thereby avoiding the deep holes in the old channel, which offer great impediments in the construction of coffer-dams, and gaining the advantage of a nearly straight line of channel from the head of Sycamore Chain to the head of the rapids. Pilots and other river-men applaud this

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change, and it has in fact already proved to be a great advantage to navigation.

A coffer-dam of 2,209 feet in circuit, in an average depth of about 4.3 feet below low water of 1864, and with ten cribs, was commenced on the 26th of July, and on the 28th of the following September the excavation was completed, accepted, and paid for by you, to the amount of 5,598.87 cubic yards.

In the mean time two chisels and a dredge were working at a patch in the channel about 500 feet distant from the head of the coffer-dam. This patch, called Center Patch, and some strips of rock upon which the head and foot of the coffer-dam rested, altogether amounting to 842.5 cubic yards, were removed, and on the 30th of October the work was accepted and paid for.

II. *Upper Chain, or so-called "opening at Smith's Chain."*—The channel at the head of the rapids was very deep, but too narrow for easy navigation. It was determined to give it a width of 200 feet by cutting away a strip of rock from the Iowa boundary of the channel, and a coffer-dam was built for this purpose of 1,710 feet in circuit, in an average depth of 3.3 feet below low water of 1864. This dam was begun at about the time of the completion of the large dam at Smith's Chain; the rock was removed to the amount of 3,697.5 cubic yards, and the work accepted and paid for on the 30th of October. The strip of rock on which the side of the coffer-dam nearest the Illinois shore had rested was afterward removed by chisel and dredge, and on the 20th of May, 1872, the excavation, to the amount of 991.30 cubic yards, was accepted and paid for.

III. *Between Smith's and Sycamore Chains.*—Between these chains there existed a very crooked and dangerous channel. Patches of rock of greater or less area extended into the channel from the sides, and, furthermore, numerous patches of small extent lay scattered in mid-channel. It was decided to inclose the larger areas of intruding rock by coffer-dams, and to remove the smaller dispersed patches by means of chisel and dredge. There were two dams constructed.

(*a.*) *Upper coffer-dam.*—This dam, of 960 running feet, in an average depth of 5 feet below low water of 1864, was commenced on October 1, 1871, and on the 20th of the same month 805.1 cubic yards of rock had been removed, accepted, and paid for.

(*b.*) *Lower coffer-dam.*—This dam, of 840 running feet, in an average depth of 5.9 below low water of 1864, was commenced on October 3, 1871, and on the 28th of same month 817.2 cubic yards of rock had been removed, accepted, and paid for.

(*c.*) *Chisel and dredge work.*—This work was begun during October, 1871, continued until close of navigation, resumed this year, and completed May 15, 1872, at which time the work was accepted and paid for.

IV. *Crab Island.*—The nature of the channel at this locality was similar to that above mentioned between Smith's and Sycamore Chains, requiring in like manner the construction of two coffer-dams and the use of chisel and dredge.

(*a.*) *Upper coffer-dam.*—This dam, of 1,100 running feet, in an average depth of 6.8 feet below low water of 1864, was commenced at the end of October, 1871; 1,077.4 cubic yards were removed, and the work was accepted and paid for November 27, 1871.

(*b.*) *Lower coffer-dam.*—This dam, of 1,020 running feet, in an average depth of 5.2 feet below low water of 1864, was begun in the latter part of October; 1,446.9 cubic yards were removed, and the work accepted and paid for on November 16, 1871.

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(c.) The chisel-work at this place was begun early in June, 1872; 409 cubic yards have been removed, and the work accepted and paid for.

V. *Saint Louis Chain.*—Numerous soundings were made in the fall of 1871 on this chain, in addition to those of 1867 and 1868. After plotting these soundings, the plan which had previously obtained in regard to the improvement of this chain was changed by you.

The channel is deep and wide, with the exception of the part called Saint Louis Cabin Passage. At this point (speaking with reference to a plane 4 feet below low water of 1864) lie two islands, averaging in elevation above said plane 1.5 feet. These form three passages, of which, at low water, the largest is not more than from 60 to 70 feet in width. Only two of these passages can be used, those nearest the Iowa boundary line of the channel, the third being too crooked for the long Mississippi steamers.

The first idea was to remove both islands, but after carefully considering the matter you concluded to remove but one of the islands and so much of the intruding rock on the Iowa boundary line of the channel as was necessary to give the improved channel a direction parallel to the general direction of the current of the river. This change is pronounced a good one by river-men, and the work was begun under your instructions by chisel and dredge in the latter part of June, 1872. As the improvement of the rapids above Saint Louis Chain has already been completed, the work of excavation is now confined to this chain. There are working at the present date four improved chisels and two dredges, day and night, and I am confident that the 2,200 cubic yards to be removed at this chain can be covered by the amount of money still available under the contract, and I can further state that this chain will be put on the list of improved chains by the middle of September, 1872. A large amount of rock has already been broken by chisel, and approximate estimates have been paid covering 1,183.2 cubic yards.

The work accomplished during the past year has been done under contract with Mr. J. J. Dull. From the very commencement he nearly doubled the means formerly used in pushing on the work, supplied two steamers, numerous flat-boats, and pumps of various patterns, and constructed a large floating carpenter, machine, and blacksmith shop.

I have to call your especial attention to the improvement of the chisel which has been effected by Mr. Whitney, superintendent for contractor. The chisel, which is operated after the manner of a pile-driver, was constructed of wrought iron, from 12 to 18 feet in length, and from 1 foot to 1 foot 3 inches in thickness. The point was made of cast steel, about 1 foot in length, wedge-shaped, and welded to the wrought-iron shank. In this shape it was used by the former contractors. When the point became dull, and the chisel in consequence ineffective, the whole mass, weighing from three to four tons, was transported to Chicago to be sharpened, involving great loss of time and great expense, the chisel-boat being in the mean time inactive. Mr. Whitney substituted a movable steel point of about 3 feet in length and 1 foot in thickness, (the so-called Whitney point,) such that when dull it can be quickly removed and another substituted in its place, a supply of about twenty points being always kept on hand. Mr. Whitney has also more than doubled the number of strokes per minute, by a change of gearing; has improved the head-block and the mode of attaching the chisel to the head-block, and in fact transformed the chisel into an effective instrument for rock-excavation, by means of which patches of rock, of too small extent to justify the construction of a coffer-dam, can

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be removed rapidly and cheaply. A head-light on each of the chisel-boats enables them to operate at night.

I am constrained to acknowledge that through the energy of Mr. Dull the work has been pushed on with far greater rapidity than the same class of work was ever executed by former contractors, and the quality of the work performed during the past year excels by far any previously done on the rapids improvement. Moreover, the former contractors had the advantage of a less number of running feet in coffer-dam building, in comparison with the amount of rock to be excavated in the pit. For illustrating this case, I mention that the former contractors, working Moline Chain, put in 3,200 running feet of coffer-dam, and excavated in the pit 17,000 cubic yards during six months, whereas Mr. Dull was obliged to build six different coffer-dams, comprising 7,818 running feet, and 32 cribs, and he took out 14,000 cubic yards in four months.

The engineering work, involving the laying out of coffer-dams, surveys in the pits, calculations, &c., was done, under your direction, by myself and Mr. C. H. Beuck, assistant civil engineer, and required close attention, as the work of excavation was carried on simultaneously at different points over a long stretch of channel; yet the force of rodmen, boatmen, &c., has not materially exceeded that employed in former years. In the pit surveys, squares of 5 feet side were laid out, and the calculations made from the average of the levels taken at the four corners of the square. As soon as the contractor reported the work completed at any given point, I made personal inspection, and satisfied myself that the work had been executed according to contract. All the calculations pertaining to coffer-dams, together with the notes of the final inspection of the same, have been bound in books, and to each book affidavits in relation to correct surveys and computation have been attached, and thus submitted to you for acceptance and payment.

The quantity of rock as found by actual survey in the pits of coffer-dams, as compared with the quantity obtained by calculation from the hydrographic maps in this office, has never shown a greater difference than 3½ per centum, and confirms previous statements made in regard to their value.

I have to call your attention to the benefits arising from the insertion, on your part, of the clause in the contract to the effect that no payment would be made for excavation below grade occasioned by stratification, or carelessness of workmen, and I can state with certainty that at least 20 per centum has been saved thereby; and, furthermore, it has developed the fact that it is possible to keep closely to the plane of grade, thereby throwing new light on certain claims, made by former contractors on this improvement, against the United States.

The following table shows the amount of rock excavated under the contract with Mr. J. J. Dull, up to 15th August, 1872:

Summary.

Locality.	Quantity in cubic yards.	Contract price.	Amount.
Smith's Chain	6,441.37	$10 35	$66,668 17
Opening at Smith's Chain	4,688.08	14 00	65,643 20
Between Sycamore and Smith's	3,317.00	11 00	36,487 00
Crab Island	2,933.03	11 50	33,732 95
Saint Louis Chain	1,183.02	16 00	18,931 20
Total	18,563.67		221,462 52

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There remain at Saint Louis Chain about 1,000 yards, the excavation of which will finish the chain and exhaust the appropriation.

Extensive soundings were made during the fall of 1871, under your direction, for ascertaining the obstructions to navigation between the chains already improved, and also for investigating the subject of a system of signals for day and night, as an aid to steamers in keeping the channel. In this connection I most respectfully refer you to an accompanying report by Mr. C. J. Pauli, assistant civil engineer.

The employés of this office, Messrs. Pauli, Durham, and Wallace, civil engineers, have ably assisted me in carrying out your orders, and I take pleasure in bringing to your notice their faithful performance of the duties intrusted to them.

Considerable additional work in the office has been occasioned in the copying of maps, papers, &c., relating to claims of former contractors, Case & Co. *vs.* United States, and at this very day there is a requisition for maps and papers for the use of the Court of Claims, the preparation of which will consume the time of two assistants during the next four months.

The work assigned to the new appropriation for the fiscal year 1872–'73 is under advertisement, and the bids will be opened on the 24th of August. The intention is to remove the obstructions at Winnebago Island, and also certain patches of rock between this island and Campbell's Chain, as well as others between Campbell's Chain and Saint Louis Chain, which being completed the improvement will be finished from the head of the rapids to the head of Duck Creek Chain.

I respectfully submit below a description of the places remaining to be improved, with the number of cubic yards of rock to be excavated, and an estimate of the cost of the same, which I fully believe will cover the expense of removing the remaining obstructions, and of completing a work which, in magnitude and advantage to be derived from it, excels by far anything of the kind ever attempted in this or any other country, and which will, in the years to come, indirectly repay with interest the money which has been spent upon it, in the immunity from loss in navigating this, the most difficult portion of the Upper Mississippi River.

1. *Lower Chain.*—The channel, here very crooked, should be straightened, and a number of patches removed, amounting to about 5,000 cubic yards.

2. *Foot of Moline Chain.*—The channel is here very crooked, and long steamers coming from below at low stages of the river experience great difficulty in passing the foot of the chain previous to entering the improved channel above. A swift current, of from six to seven miles per hour, increases the danger. About 3,400 cubic yards should be removed to perfect this part of the chain.

3. *Head of Duck Creek Chain.*—Certain patches setting out into the channel compel steamers coming down to make a sharp curve before entering upon the improved channel, in doing which they frequently strike the rock. About 600 cubic yards should be removed.

The total amount would be 9,000 cubic yards, which, at the average price of $12 per yard, would cost $108,000, which is the sum needed for completing the improvement of the Rock Island Rapids of the Mississippi River.

All of which is respectfully submitted.

Your obedient servant,

E. F. HOFFMANN, *C. E.*,

Assistant in local charge U. S. Improvement Rock Island Rapids.

Colonel J. N. MACOMB,

Corps of Engineers, U. S. A., Rock Island, Illinois.

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H 22.

IMPROVING THE ROCK ISLAND RAPIDS.

UNITED STATES ENGINEER OFFICE,
Rock Island, November, 1871.

MAJOR: I have the honor to submit to you the following report in regard to the soundings made during the months of September and October, 1871.

Being intrusted by you with the charge of the sounding-party, I started up the river on the 19th of September, 1871, having instructed the men on the previous day to make soundings in the proper manner.

Your orders were to sound the margins of the channel on the Rock Island Rapids, between the different "chains," in order to determine the width and shape of the same, from Le Claire to Davenport; to sound "patches" near Winnebago Island, foot of Moline Chain, Lower Chain, and make additional soundings at Saint Louis Chain.

The steamer Park Painter, Captain Dorr, was chartered for towing the sounding-boats over the places to be sounded, and these boats, seven in number, were so attached to the steamer's bow as to lie in a straight line, 100 feet in length, at right angles to her center line. Ten sounders were distributed along this line, each one having his recorder.

In previous surveys you had located the direction of the line of the boats by use of a prismatic compass, placed on one of the end boats, but this year you improved upon this method by using a theodolite placed on the boat nearest to the base-line, and observed the angle formed by this theodolite, the upper theodolite on shore, and the line of sounding-boats.

Four soundings and two instrumental observations per minute were taken; otherwise, the *modus operandi* was the same as in former surveys.

A quarter-boat was furnished for the comfort of the party, and the outfit was in every respect complete.

The party consisted of the following: 2 observers of theodolite on shore, Messrs. J. F. Wallace and H. Lambach; 1 observer of theodolite on the boats, Mr. C. Durham; 1 foreman of sounders, 1 flagman and time-keeper, 10 sounders, 1 reserve sounder, 2 boatmen, 3 recorders for instruments, (boys,) and 10 recorders for sounders, (boys.)

On the 20th of September soundings were made near Winnebago Island, and on the next day we moved up to Smith's Chain, and commenced to sound the channel.

The stage of water being rather low, varying from 0.9 feet to 1.8 feet above low water of 1864, soundings on shallow places could be made very accurately, but we were frequently delayed by grounding on the rocks.

We made the following soundings:

Between Smith's and Sycamore Chain	9,6[illegible]
Between Sycamore Chain and Crab Island	3,6[illegible]
Between Crab Island and Saint Louis Chain	6,6[illegible]
Between Saint Louis and Campbell's Chains	32,1[illegible]
Between Campbell's Chain and Winnebago Island	10,1[illegible]
Between Winnebago Island and Duck Creek Chain	28,7[illegible]
Between Duck Creek and Moline Chains	31,8[illegible]
Between Moline and Lower Chains	17,3[illegible]
On Saint Louis Chain	5,7[illegible]
On foot of Moline Chain	12,6[illegible]
On patches near Winnebago Island	9,8[illegible]
On Lower Chain	28,[illegible]10
Between Lower Chain and old bridge	2,51[illegible]
Soundings to examine chisel and dredge work on certain patches at Smith's Chain	2,0[illegible]
Total	201,19[illegible]

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I found the channel in most localities of very good width, and at some places of considerable depth. For instance, between Smith's and Sycamore Chains, I discovered places where, with a 50-foot line, I was unable to touch bottom. In the channel above Duck Creek Chain, at foot of Moline, and at Lower Chain, however, I found great obstructions to navigation, and I was also, during my stay on the river, repeatedly informed by pilots of this fact, but as I have not yet plotted the work, I am, of course, unable to state the extent of these obstructions.

Base-lines for soundings were partly established in former years, and I used several of them, but in many cases I had to lay out new ones, as the old station-stones had been destroyed or removed by ice.

Bench-marks had been established along the river on both shores previous to soundings, the references of which were taken from a reliable low-water mark established in 1864, near Sycamore Chain.

Below Moline Chain were taken 14,990 soundings, being the largest number in one day.

Finally, I have to state that this party, organized by you, was composed of reliable men, and the assistants performed their duty from beginning to end in the most faithful and satisfactory manner.

On the 28th of October I, having finished the survey, discharged the party, and reported to you in this office for further duty.

All of which is respectfully submitted.

Your obedient servant,

C. J. PAULI.

UNITED STATES ENGINEER OFFICE,
Rock Island, Illinois, August 15, 1872.

Since the above report has been written, the plottings of the soundings at Lower Chain, foot of Moline Chain, and Duck Creek Chain, have been effected. They confirm what I stated in my report of November, 1871. The following amounts have been originated from these plottings:

	Cubic yards.
1. Lower Chain, about	5,000
2. Foot of Moline Chain, about	3,400
3. Duck Creek Chain, about	600
Total	9,000

All of which is respectfully submitted.

Your obedient servant,

C. J. PAULI.

Major E. F. HOFFMANN, *C. E.*.
Assistant in local charge of Rock Island Rapids Improvement.

APPENDIX I.

ANNUAL REPORT OF LIEUTENANT-COLONEL W. F. RAYNOLDS, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

ENGINEER OFFICE, UNITED STATES ARMY,
1122 *Pine street, Saint Louis, Missouri, August* 12, 1872.

GENERAL: I have the honor to submit this, my annual report of

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operations upon the improvement of the Mississippi, Missouri, and Arkansas Rivers.

The operations of the snag-boat fleet comprise all the improvements which have been carried on under my direction on the streams named.

In my last annual report I stated that after the completion of the requisite repairs upon the several boats they resumed operations in the field as follows: The snag-boat S. Thayer, May 31, 1871; the snag-boat J. J. Abert, June 13, 1871; the dredge-boat Octavia, June 17, 1871; the snag-boat R. E. DeRussy, July 9, 1871; the snag-boat S. H. Long, July 18, 1871.

Very respectfully, your obedient servant,

W. F. RAYNOLDS,
Lieutenant-Colonel Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

I 1.

OPERATIONS IN MISSOURI RIVER.

Navigation in the Missouri, above Omaha, is too uncertain to trust any but our light-draught snag-boat in this portion of the river. The commerce of the stream above Sioux City is confined to the spring of the year, when boats are dispatched to the head-waters of the stream to supply the mining regions of Montana and the military posts above Fort Randall. Owing to the small appropriation and the lack of facilities, no attempt has ever been made to extend the operations of the snag-boats above Sioux City; during the past season it was not practicable to work above Omaha.

The snag-boat S. Thayer was assigned to the portion of the river between that place and Saint Joseph, Missouri. She passed entirely over her beat, removing snags and trees from the banks, both on her upward and downward trips, and left the river in a better condition than it ever was before for navigation.

The snag-boat R. E. De Russy was assigned to that portion of the river between Saint Joseph and Lexington, Missouri,. The S. H. Long was ordered to work between Lexington and Eureka, Missouri, and the J. J. Abert was assigned to the beat between Eureka and Saint Louis. These boats all passed over their beats twice, and did effective service.

The total number of miles run by the boats in the Missouri was	3,996
The total number of snags removed	2,226
The total number of trees cut from the banks	12,101
The estimated weight of the snags taken from the channel was, tons	24,411
The estimated rack-heaps removed	72

Before the De Russy and Long had finished their work, the river had become so low that it was impossible for them to get over some of the bars. They were detained for nearly a month, and it was only by sending the Octavia to their aid, and by building floats between the hulls and removing everything movable from them that they were able to get out of the stream. A full account of the trip of the Octavia when she was sent to their relief, was forwarded to you at the time. It is referred to now to call attention once more to the necessity of having a different class of boats for the work that is expected of us.

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OPERATIONS IN THE MISSISSIPPI RIVER.

The dredge-boat Octavia was employed in the Mississippi River, between Cairo and Keokuk, dredging the shoals for the purpose of improving the navigation. She passed over her route twice—both ways—and continued her operations until it was necessary to send her into the Missouri to aid the large snag-boats in getting out of that stream.

The dredging in the Mississippi was not expected to furnish permanent relief to navigation, the shoals being of so shifting a character that a rise in the water fills up any cut which can be made. The *temporary* relief afforded was very decided.

The snag-boat J. J. Abert operated in the Mississippi River after leaving the Missouri, (August 26,) until the last of December, when she was transferred to the Saint Francis River. Her beat (in the Mississippi) was Saint Louis to Memphis.

After the snag-boat S. H. Long was released from the Missouri, (October 16,) she was occupied for about ten days at work removing wrecks from this harbor. Subsequently, until the 31st of December, she worked in the Mississippi River, between Memphis, Tennessee, and the mouth of White River. On the 1st of January, 1872, she was transferred to the Arkansas River.

The snag-boat R. E. DeRussy reached Saint Louis, after her detention in the Missouri River, on the 16th of October; from that date until the end of the month she operated between the mouth of the Missouri and the mouth of the Des Peres, mainly on wrecks in this harbor.

The city authorities of Saint Louis having expressed great anxiety to have one of the snag-boats detached especially for duty in this harbor, I informed them that I did not think it would be justice to the general interest of commerce to expend any larger proportion of a small appropriation for what might be regarded as a local benefit, the operations of the Long and DeRussy having secured a good navigable channel in front of the city. But as the boats would, of necessity, be laid up for some months, owing to the want of money to run them, if the city was willing to pay running expenses, I would ask the approval of the Department to letting one of the boats work for a time in the harbor. This proposition was accepted by the city, and by authority of the Engineer Department the DeRussy continued work in this harbor during the month of November, under the direction of the harbor-master, removing wrecks and other obstructions, the city paying all her expenses during the time.

The harbor-master, in his annual report, speaking of the operations of the Long and DeRussy, says:

> In relation to the removal of wrecks, I would state, some time in May last the barge belonging to the Northwestern Packet Company was sunk loaded with railroad-iron, at the foot of Elm street, outside of the Mississippi Valley Transportation Company's wharf-boat, and when the water fell it became necessary to have the wreck removed, as it prevented the company from landing their barges alongside of the wharf-boat. I then advertised for proposals to remove the wreck, and found, by different propositions, the lowest bid was abont $3,500, and of no assurance of it being removed before the first of December. The matter was referred to the harbor-committee, and was laid over. In the mean time the arrival of the United States snag-boats was looked for daily. Mr. Henry Kaiser, our worthy city comptroller, and the gentlemen composing the harbor-committee, made arrangements with General Raynolds, United States engineer of the western river improvements, for the snag-boats S. H. Long and De Russy to remove this and other wrecks that were a very great obstruction to the channel of the river, and to commerce generally. The snag-boat S. H. Long succeeded in removing from the wreck of the steamer Governor Sharkey sunk at the foot of Anna street, all that was an obstruction, leaving 8 feet of water over the wreck, or 5 feet more water than there was in the channel during the low water of 1863.

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The snag-boat Long, before removing the wreck of the Sharkey, succeeded in removing the wreck of the barge sunk outside of the Mississippi Valley Transportation Company's wharf-boat. The removal of these two wrecks by the Long saved the city about $8,500, without any cost to the city for the use of the snag-boat S. H. Long.

The snag-boat De Russy was, at the same time, working at what was supposed to be the wreck of the steamer Fannie Sparhawk, and a wharf-boat sunk by the ice some years after, and succeeded in removing all of the wrecks that was necessary to leave 5 feet of water above the low-water mark of 1863. The next work of the De Russy, under arrangements made by Mr. Henry Kaiser and the harbor-committee, for the removal of all portions of the wrecks of the steamers White Cloud and Belle Memphis. After some ten days' work, she succeeded in removing all of that portion of both wrecks that obstructed the navigation, leaving, as in the former instance, about 5 feet above the low water of 1863, and increasing the channel-depth on the Missouri side of Arsenal Island from 5 feet to 8 feet, without any additional rise in the river, leaving the current of the river to pursue its natural course. After the removal of a portion of the wrecks of the White Cloud and Belle Memphis, then the De Russy proceeded to remove the wreck of the burnt steamer Dictator, burnt in the winter of 1866, at the foot of Elm street. When the De Russy commenced the wrecking of this hull, there were scant 3 feet 6 inches of water on the gunwales or sides of the boat.

The snag-boat, after blasting and wrecking up to the 28th day of November, 1871, succeeded in removing the larger portion of the wreck, and, had not the ice interfered, would, in a few days, have removed the whole entire wreck. As it was, they succeeded in removing enough to leave about 6 or 7 feet of water, where there was but 3 feet 6 inches of water, giving the city of Saint Louis about 100 feet more wharf in low water than she would have had had not the work been done.

The employment of the United States snag-boats S. H. Long and De Russy has saved the city of Saint Louis $15,000, as the whole work done by the United States snag-boats would have had to be done as soon as the other parties could have possibly done it, in order to prevent the channel of the river leaving the Missouri side of Arsenal Island, and the danger of sinking steamboats.

The total expense of the two snag-boats, submarine armor, and divers, and material that was necessary for the work, was about $6,000. There were seven wrecks in all that were removed, or, as stated before, that would at the least calculation cost the city of Saint Louis between $20,000 and $25,000.

OPERATIONS IN ARKANSAS RIVER.

The snag-boat S. H. Long operated in the Arkansas River from the 1st of January until she was laid up on the 13th of February. Her beat was from the mouth of the river to Silver Lake Landing; her great draught rendering it unsafe to trust her far up the stream.

The snag-boat S. Thayer, after operating in the White, Black, and Little Red Rivers, during the months of November, December, and January, was transferred to the Arkansas, where she continued operations during February and March, when she was transferred to the Saint Francis. Her beat in the Arkansas was from the mouth to Pine Bluff.

A condensed statement of the amount of work done during the year is given in the following table:

Operations of the United States dredge and snag-boats during the fiscal year ended June 30, 1872.

Name of boat	Rivers.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Drift piles removed.	Number of miles run.
Octavia	Missouri					399
	Mississippi	9	39.2	258		7,477
	Ouachita	183	1,117.2	6,308	1	1,435
	Total	192	1,156.4	6,566	1	9,311
J. J. Abert	Missouri	519	3,014.9	2,602	9	347
	Mississippi	631	6,379.8	2,153	6	1,436
	St. Francis	269	1,535.1	112		128
	Total	1,419	10,929.8	4,867	15	1,911

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Operations of the United States dredges and snag boats, &c.—Continued.

Name of boat.	Rivers.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Drift piles removed.	Number of miles run.
S. Thayer	Missouri	645	4,547.8	896	17	1,155½
	White	543	4,598.3	422	3	987
	Arkansas	275	3,454.3	66	1	294
	Mississippi	1	1.6	.....	.....	1,370
	St. Francis	162	1,814.1	39	2	89
	Total	1,626	14,416.1	1,423	23	3,895½
R. E. DeRussy	Missouri	676	9,403.6	.....	34	1,321
	Mississippi	366	12,422.9	71	.....	1,841
	Black	17	290.7	.....	.....	97
	Ouachita	168	1,531.7	3,969	.....	786
	Total	1,227	23,648.9	4,040	34	4,045
S. H. Long	Missouri	386	7,444.7	8,603	12	773½
	Mississippi	358	11,324.2	139	6	1,640
	Arkansas	267	5,505.0	191	1	206
	Total	1,011	24,273.9	8,933	19	2,619½

Summary for the fiscal year.

Missouri	2,226	24,411.0	12,101	72	3,996
Mississippi	1,365	30,167.7	2,621	12	13,764
Ouachita	351	2,648.9	10,277	1	2,221
St. Francis	431	3,349.2	151	2	217
White	543	4,598.3	422	3	987
Black	17	290.7	.....	.....	97
Arkansas	542	8,959.3	257	2	500
Grand Total	5,475	74,425.1	25,829	92	21,782

The following table shows the cost of wages, fuel, and provisions of each boat during the past two seasons, together with the number of days in commission and the cost per day. A very decided decrease will be observed in the daily expenses of the last year over the previous one, due, I believe, mainly to our having learned, by experience, how and where to save.

Name of boat.	Season.	Fuel.	Wages.	Stores.	Total.	Number of days in commission.	Cost per day.
United States dredge-boat Octavia	1870–'71	$2,097 94	$10,219 25	$3,919 11	$16,236 30	109	$148 96
	1871–'72	7,840 95	19,583 47	5,114 59	32,539 01	259	125 63
United States snag-boat J. J. Abert	1870–'71	3,589 85	11,336 99	4,875 99	19,802 83	150	132 00
	1871–'72	5,343 62	19,201 02	3,746 04	28,290 68	288	98 23
United States snag-boat R. E. DeRussy	1870–'71	4,970 01	12,008 01	4,386 85	21,364 87	155	137 84
	1871–'72	5,908 72	17,404 58	4,161 95	27,475 25	231	118 94
United States snag-boat S. H. Long	1870–'71	5,019 57	14,024 38	5,273 26	24,317 21	186	130 74
	1871–'72	5,134 11	18,391 14	3,808 66	27,333 91	228	119 88
United States snag-boat S. Thayer	1870–'71	3,118 25	12,314 33	4,023 31	19,455 89	187	104 04
	1871–'72	4,610 67	20,116 50	4,243 35	28,970 52	346	83 73

It is believed that the fleet of snag-boats are run as economically as is practicable on these rivers, and that the work done by them would not be done as cheaply by contract. In proof of this I would call attention to the extract given above from the report of the harbor-master on the work done by the Long and DeRussy, in the harbor of Saint Louis. It

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is but fair to say that the city did not pay for all the work done; but $4,000 is a large estimate for the expense of the boats while on the work and not under pay from the city. This, added to the cost of the city, ($6,000, as stated by the harbor-master,) make a total cost of $10,000 for work which could not have been done by contract for less than $20,000 or $25,000. This was the case in the harbor of Saint Louis, with all the appliances of a great city at command. In the out of the way localities in which our boats generally work the saving would be much greater.

During the past year, an earnest effort, continued through nearly six months, was made to estimate the total value of the commerce benefited by the operations of the snag-boats. The attempt only showed us that reliable data could not be obtained. This is strictly a domestic commerce, where there is no occasion to guard against smuggling, and boats are not required to make returns. It is only by getting the records of each and every boat, and compiling them, that a fair estimate could be made. This was attempted, but as these records were sometimes on the boat, at the others in the office of the agents or owners, and usually packed away, it was found that the parties having possession were seldom inclined to take the trouble necessary to furnish them. Estimates of the total value of the commerce of the western rivers have been made by different parties, varying from one to two thousand millions of dollars. I respectfully suggest the propriety of some legislation to require from all boats returns of their manifests, in order that the value of the commerce may be known with some degree of exactness.

The necessity of making provision for the continuance of the operations of the snag-boats, by building new boats to replace those we now have, has heretofore been repeatedly urged. The time is fast approaching when new hulls must be provided or we shall have no boats. The item of repairs has already become so great as to absorb a large part of the appropriation. Water-logging and extra timber to keep up strength has added 6 inches to their draught of water. I am satisfied that nothing but iron hulls will give us the boats we want, and even if this were not the case, it would seem proper for the Government to foster the building of iron-boats on our western rivers. An appropriation for this purpose is most urgently recommended.

PROPOSED WORK FOR THE COMING YEAR.

The appropriation for the improvement of the Mississippi, Missouri, and Arkansas Rivers, made by act of Congress approved June 10, 1872, was $90,000.

The condition of the fleet is such that I have recommended, and the Department has approved, setting aside the sum of $40,000 of this sum to commence building an iron hull for one of the boats. This leaves but $50,000, with the balance of the previous appropriation, for running the fleet during the year. The cost of all the boats in commission cannot be estimated at less than $20,000 per month, which would consume all our funds in about three months. This being the case, one of the boats (J. J. Abert) has, at my suggestion, been turned over to Major W. E. Merrill for service in the Ohio River, under the appropriation of $200,000 for the improvement of that stream. The Octavia has been laid up for want of funds to run her, and I propose keeping the remaining three boats in commission an average of about five months each. This time I have proposed to distribute about as follows:

Two boats, two months each in the Missouri.

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Two boats, three months each in the Mississippi.

One boat, five months in the Arkansas.

The above programme does not provide for the removal of the machinery of one of our boats to the new hull it is proposed to build, nor for making the repairs which will be indispensable at the close of the season's operations.

The small appropriation compels us to rely for these items upon appropriations to be made by the coming Congress.

The following estimates are submitted for continuing the operations of the fleet during the fiscal year ending June 30, 1874.

For the improvement of the Mississippi River.

For running expenses of four snag-boats, six months each, twenty-four months, at $5,000 per month	$120,000
For running expenses, including repairs of one dredge-boat throughout the year, twelve months, at $5,000 per month	60,000

For the improvement of Missouri River.

For running expenses of four snag-boats, six months each, twenty-four months, at $5,000 per month	$120,000

For the improvement of Arkansas River.

For running expenses of four snag-boats, five months each, twenty months, at $5,000 per month	$100,000

For additional facilities for improving western rivers.

For the construction of two double-hull snag and wrecking-boats, at $100,000 each	$200,000

I 2.

IMPROVEMENT OF THE OSAGE RIVER, IN MISSOURI.

The obstructions in this stream consist of numerous shoals, having from 12 to 18 inches of water upon them. The pools between the shoals are deep enough at all times to accommodate the commerce of the river.

The previous examination of this stream not being sufficiently minute to determine exactly the locality or amount of the work to be done, the Department approved my recommendation to make the improvement by employing hired labor.

Mr. Alonzo Livermore was employed to take the supervision of the work, and it was determined to make channels through the shoals by the use of horses and ordinary scrapers. Mr. Livermore was on the ground with a small party ready to commence work early in July, but during the whole of that month and the month of August the river remained so high that scrapers could not be used. The prospects of low water seeming remote, efforts were made to procure a dredging-machine, and negotiations commenced for one from the Illinois River, when a dispatch was received from Mr. Livermore that the Osage had fallen so rapidly that an ordinary sized dredge could not enter it.

Early in September a supply of scrapers was procured, and Mr. Livermore was directed to commence work on the lower shoal, and to continue it as rapidly as possible, up stream, as far as practicable.

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Some difficulty was found at first in procuring teams. It was, however, overcome, and after the work was fairly commenced there was no difficulty in procuring the requisite men and teams at reasonable rates.

Work was commenced on the 25th of September and carried on until 3d of November, a period of thirty-four working-days, when the river had risen so much as to preclude further operations with teams, and the work of excavation was accordingly closed for the season; a few leaning trees were subsequently cut from the bank near Shipley's Shoal.

The estimated quantity of material excavated with scrapers is 11,200 yards; of this 9,600 yards were removed from the lower seven shoals, at an estimated cost of 25 cents per cubic yard. The two shoals succeeding these seven, viz, Round Bottom and Dixon's Shoals, cost about 60 cents per cubic yard for the 1,600 yards removed; the material in them being harder and more compact than the others, and the work having been done after the river had somewhat risen. The work on Round Bottom and Dixon Shoals was not completed. A number of logs and stumps were also removed from the channel by means of teams.

Repairs were made upon such of the wing-dams (erected some years ago by the State of Missouri) as required them. Materials used were brush and stone, the latter quarried by the working party.

The details of the work done upon the several shoals is as follows:

	Cubic yards
Shipley's Shoal, (the lowest)	3,000
Price's	400
Rice's	800
Botton's	2,600
Locket's	400
Locket's Island	400
Burd's	2,000
Round Bottom	800
Dixon's	800
Total excavated	11,200

The repairs upon wing-dams were at Shipley's, Botton's, Round Bottom, and Dixon's Shoals.

The effect of the work done was to afford very decided relief to the navigation during the season of low water. The permanency of the channels excavated is yet to be determined. It is probable that many of them will have to be protected by brush and stone revetments. If the channel it is proposed to make can be made permanent, it will be a great benefit to commerce, but it can hardly be doubted that the time will come when locks and dams will be called for.

OPERATIONS FOR THE COMING SEASON.

A party is now engaged making the necessary examination to determine the effect of last season's work, and to enable us to lay out the work for the present season.

It is proposed to attempt the deepening of the shoals the present season, by contract, and proposals have already been invited for doing the work.

The appropriations already made, it is hoped, will be enough to test the method of improvement adopted in that portion of the stream between the mouth and Tuscumbia. If it is proposed to carry the work above that point appropriations will be required in accordance with the original estimates in the report forwarded from this office dated Decem-

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ber 28, 1870, and published in House of Representatives Ex. Doc. No. 60, Forty-first Congress, third session, which were:

For the improvement of the whole stream	$200,000
Less amount of two appropriations	50,000
Leaving to be appropriated	150,000

I 3.

IMPROVEMENT OF WHITE, BLACK, AND LITTLE RED RIVERS, ARKANSAS.

The Department having approved my recommendation to expend the appropriation for the improvement of these streams by paying the expenses of our light-draught snag-boat while engaged removing snags and other obstructions from the channel, the snag-boat S. Thayer was sent into White River and operated therein, and in the Little Red and Black Rivers, from the 9th of November, 1871, to the 31st of January, 1872. Owing to the want of water and the extremely short bends she was able to do but little in the smaller streams. She reached People's Bend in the Little Red, but could get only a short distance above the mouth in Black River. The amount of work done was as follows: Number of snags pulled, 543; number of trees cut, 422; number of drift piles removed, 3.

Unless other and better facilities are provided in the shape of a properly constructed light-draught snag-boat it will be of little use to attempt to remove the obstructions in such streams as these.

Amount expended during the fiscal year ending June 30, 1872	$8,018 89
Amount available July 1, 1872	1,981 11

The construction of a small iron snag-boat for operating in these and similar streams would probably cost $75,000.

I 4.

IMPROVEMENT OF SAINT FRANCIS RIVER, ARKANSAS.

The Department having approved my proposition to use one of our snag-boats for the improvement of this stream, the snag-boat J. J. Abert was sent into the Saint Francis on the 1st of January, 1872. She reached Cow Island, about thirty-seven miles above the mouth, when the river falling suddenly she was unable to proceed either up or down stream, and remained comparatively idle for a period of thirty days, when a rise in the river enabled her again to reach the Mississippi.

Subsequently the snag-boat Thayer, of lighter draught, was sent into the stream, and operated there during the month of April.

The amount of work done in the Saint Francis was as follows:

Boats.	Number snags pulled.	Weight in tons.	Number trees cut.	Drift-piles removed.
J. J. Abert	269	1,535.1	112	.....
S. Thayer	162	1,814.1	39	2
Total	431	3,349.2	151	2

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The necessity of properly constructed boats for operating on all the western rivers, and especially in the smaller streams, has been so often urged ineffectually that it seems almost hopeless again to allude to it. There should be at least three large new boats for the larger streams, and two of less dimensions every way for the tributaries. Unless they are furnished soon the snag-boat fleet will be a thing of the past, and even while the boats we have may last, the work will be done expensively as well as indifferently.

Amount expended during the fiscal year ending June 30, 1872, $10,000.

I 5.

IMPROVEMENT OF THE LITTLE MISSOURI RIVER, IN ARKANSAS.

An appropriation of $10,000 having been made, and the Department having approved my recommendation to do the work by hired labor, it was determined to add the general supervision of this stream to the duties of Mr. Justin Straszer, who had been employed for the improvement of the Ouachita. The immediate charge of the working party was given to Mr. T. R. Tennison, an experienced pilot for the stream. The outfit consisted of a flat-boat, 60 feet long, by 16 feet wide, supplied with hoisting apparatus for removing snags, and axes and saws for felling and cutting up trees. The boat furnished quarters for the working party.

On the 12th of July Mr. Tennison started with his flat from Tate's Bluff, at the junction of the Ouachita and Little Missouri, and proceeded up the river, clearing out such obstructions as prevented the passage of his boat, or were most immediately in the way.

On the 9th of August the party reached Gasney's Ford, five miles below Natchitoches Bluff, the point to which it was proposed to improve the stream. The river betwen the ford and the bluff being very winding, the laborers were sent across the short necks by land to fell the timber, which saved the boat the labor and loss of time required in pulling round the bends to the bluff.

This part of the work was finished by the 12th of August, when Mr. Tennison, retracing his steps, worked back to the mouth, removing logs and snags, and cutting the leaning timber. He reached Tate's Bluff, the starting point, on the 1st of November.

The improvement had only been projected as far as Natchitoches Bluff, the appropriation seemingly not warranting any greater outlay of work.

The citizens of Okolona were very anxious to get the obstructions in the river, between Natchitoches Bluff and the mouth of Antoine Creek, (a distance of sixteen miles,) removed, and upon the return of Mr. Tennison to Tate's Bluff they offered to provide transportation for himself and party to Antoine Creek and return if he were allowed to clear out that portion of the stream. A small amount being left out of the appropriation, after Mr. Tennison had reached Tate's Bluff, he was authorized to detach a party to proceed to Natchitoches Bluff, and carry the work up to Antoine Creek, this latter place being the landing for Okolano. Sixteen days were ocupied in this work, and the most serious obstructions removed. This work concluded the party returned to Tate's Bluff in skiffs, thence the flat-boat was taken to Camden, and laid up on the 29th of November.

The appropriation for this work being less than half the estimated

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cost of completing the improvement, the work done was necessarily confined to removing the most formidable impediments to navigation. It is believed that a decided improvement has been effected, but additional work will be required before the stream is as free from obstructions as it was proposed to make it.

OPERATIONS FOR THE COMING SEASON.

Congress having made an additional appropriation of $10,000 for the improvement of this stream, it is proposed to fit out a party similar to that of last season, and to continue the work of improvement in the same manner.

I 6.

IMPROVEMENT OF THE OUACHITA RIVER, IN ARKANSAS.

By the act of Congress approved March 3, 1871, an appropriation of $25,000 was made for the improvement of Ouachita River in Arkansas.

Owing to the nature of the work, which consisted mainly of cutting trees from the banks and removing logs and snags from the bed of the stream, it was impossible to specify the work with sufficient clearness to make a contract for doing it. The Department, therefore, approved my recommendation that it should be done by hired labor.

Mr. Justin Straszer, civil engineer, and John R. Tennyson, were placed in charge of the working parties, Mr. Straszer having the general supervision. His outfit consisted of the crane-boat Ouachita, 80 feet long and 18 feet wide, built for the purpose, and fitted with steam hoisting-power, with the requisite cranes, shears, blocks, falls, &c., for hoisting, and a supply of axes and saws for felling and cutting up trees. The boat furnishing the requisite quarters for the working part, which consisted of Justin Straszer, (in charge,) first mate, second mates, one engineer, one steward, one watchman, first cook, second cook, one fireman, two deck-hands, twenty-two laborers.

Mr. Tennyson's party were on board the flat-boat Arkadelphia, 60 feet long and 14 feet wide, and supplied in the main similar to the Ouachita, with the exception of the steam-power.

The small appropriation precluded all thought of making the river navigable during the low-water stages. The object was simply to improve the general navigation and to enable boats to run somewhat longer than has heretofore been practicable.

The crane-boat Ouachita commenced operations on the 11th of July at Prior's Bluff, about fifteen miles above Camden, and worked down the river to Miller's Bluff, a distance of about sixty miles; which point was reached on the 21st of October. From there she passed rapidly down to the State line, removing only such large snags as it was supposed would be beyond the ability of the flat-boat. The work done below the State line, being under a different appropriation, is reported on in my report on the improvement of the Ouachita in Louisiana.

The flat-boat Arkadelphia, under charge of Mr. J. S. Tennyson, commenced work at Arkadelphia on the 14th of July, and carried down to Prior's Bluff, the point at which Mr. Straszer began his work, arriving at Prior's Bluff on the 30th of September. After replenishing his stores at Camden, Mr. Tennyson joined Mr. Straszer at Buffalo Shoals, on the 11th of October. From this point the two boats worked in company as

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far down as Miller's Bluff, reaching the bluff on the 21st of the month. From the bluff the flat worked alone, down to the State line, which it reached on the 19th of December, and from there she was taken to Monroe, Louisiana, and laid up for the season.

A considerable improvement has been made at Boiling-Pot Rock, twenty-four miles above Camden, by blasting out the rocks which were lying in the channel. These rocks narrowed the channel to 18 feet, and were from 12 to 18 inches above low water. The channel is now 60 feet wide, with 18 inches water on the shallowest places over the rocks.

The appropriation for this improvement was less than one-half the estimated cost of completing it. This rendered it necessary to do the work in a less thorough manner than was proposed. Instructions were given to remove such snags and trees as were the greatest impediment to navigation. The amount of work reported as having been done is fully half of what was estimated for, and all our reports from the stream confirm the opinion that a very decided improvement in the navigation has been effected.

A survey of the Ouachita from Trinity, Louisiana, to Camden, Arkansas, with a view to improving the stream by locks and dams, was made by direction of Congress during the past summer. The report on this survey was forwarded March 15, 1872, and has been published in House of Representatives Ex. Doc. No. 252.

OPERATIONS FOR THE COMING SEASON.

In view of the probability of the proposed improvement by locks and dams being carried out, it is proposed to employ our light-draught snag-boat in the stream to remove such obstructions as yet remain and would be in the way, whatever system of improvement may ultimately be adopted. It is also proposed to purchase the timber for the foundation of the two locks of the proposed improvement which will be in Arkansas, and to await further appropriations before commencing their construction.

ESTIMATE.

For the reasons stated in my report on that portion of this stream lying in Louisiana, I think that the projected improvement of this stream should consist of locks built of timber. The estimated cost, as given in the report from this office, date of March 15, 1872, and published in House of Representatives Ex. Doc. No. 252, is, for each dam and lock, $232,616.75.

The two locks and dams in Arkansas will cost	$464,233 50
Less amount appropriated	60,000 00
Leaving to be appropriated	404,233 50

As in the case of the Ouachita in Louisiana, if stone locks are deemed requisite, this amount will have to be nearly doubled.

I 7.

IMPROVEMENT OF THE OUACHITA RIVER, IN LOUISIANA.

An appropriation of $26,000 (by act of Congress approved March 3, 1871) was made for the improvement of Ouachita River, in Louisiana.

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This appropriation was made before the stream had been examined, and without definite information as to the nature of the improvement required. From our knowledge of the obstructions in Arkansas, it was assumed that much of the work to be done was the removing of trees from the bank and logs and snags from the bed of the stream. It was, therefore, determined to employ the same party in both portions of the stream. The crane-boat Ouachita, 80 feet long and 18 feet wide, was purchased, and provided with steam-hoisting power and the cranes, blocks, falls, saws, and axes for doing the work. After being employed in Arkansas, she was transferred to below the State line, and worked between that point and Monroe from the 21st of October until the 16th of December, in that time removing 42 snags and cutting over 6,000 trees from the banks.

Below Monroe the Ouachita is too large for the effective working of so small a craft as the Ouachita, especially one not provided with propelling power. It was, therefore, decided to employ a portion of our snag-boat fleet in this portion of the stream.

The dredge and snag boat Octavia and the snag-boat R. E. DeRussy were selected for this duty. The Octavia left the Mississippi on the 3d of December, 1871, and returned to it on the 12th of February, 1872, proceeding, in the mean time, as far up the Ouachita as Cold Bite Shoals, a short distance above Miller's Bluff, Arkansas, and removing 183 snags and cutting 6,308 trees from the banks.

The DeRussy left the Mississippi on the 8th of January, and returned to it on the 14th of February. She reached her highest point on the Ouachita (one hundred and twenty-eight miles below Camden, Arkansas,) February 9, and removed 168 snags and cut 3,969 trees.

The Ouachita is usually navigable below Monroe for some two or three months longer during each year than it is above. From Monroe there is railroad communication with Vicksburg, so that, if the proposed lock and dam improvement is carried out, it would seem desirable (if the funds are not provided to complete the whole work simultaneously) to have the improvement above Monroe carried out first, as this would lengthen the season of navigation throughout the entire stream, and when the lower river was not navigable the country bordering the upper portion of the stream would have the outlet by railroad from Monroe.

OPERATIONS FOR THE COMING SEASON.

It is proposed to employ our light-draught snag-boat in this stream for a few months the coming winter, to remove such obstructions as should be removed, even if the lock and dam improvement is completed, and to purchase the timber for the foundation of the single lock of the proposed improvement which is in Louisiana and above Monroe, and to await further appropriations before commencing the construction.

ESTIMATES.

In the report (forwarded from this office March 15, 1872) on the improvement of this stream, estimates were submitted for both stone and timber locks, and, as I see no reason for building more permanent structures here than is done on all the harbors of the lakes, I propose to build the locks of timber, which, it is believed, will satisfy the community, and will last twenty or twenty-five years.

The estimate heretofore submitted for each lock and dam, 49 by 250 feet, of wood, was $232,616.75.

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The three locks and dams in Louisiana would cost	$697,850 25
Less amount appropriated	40,000 00
Leaving to be appropriated	657,850 25

Especial attention is called to the fact that this estimate is for locks of *wood*, a perishable material. The estimate for stone locks of the same size was $438,983.27 each. If stone locks are deemed necessary, the appropriation must be nearly doubled.

Respectfully submitted.

WILLIAM F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

I 8.

CABARET SLOUGH.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 23, 1872.

SIR: I beg leave herewith to transmit a communication from Lieutenant-Colonel Raynolds, inclosing the report of a survey and examination made under his orders by Captain C. J. Allen, Corps of Engineers, to ascertain the practicability and cost of re-opening Cabaret Slough, in the Mississippi River, a short distance above the city of Saint Louis; being in continuation of the examinations of the river between Alton and Saint Louis, in compliance with the act of July 11, 1870, making appropriations for certain public works.

The results of previous examinations were submitted, with a letter from this office, dated March 1, 1871, and printed in Senate Ex. Doc. No. 50, Forty-first Congress, third session, and with my annual report of 20th October last.

I would renew former recommendations to improve the harbor at Alton by closing the channel west of Ellis's Island; to diminish the abrasion of the river-banks opposite the mouth of the Missouri River by clearing Mobile Chute and the slough west of Maple Island of snags and other obstructions to the free flow of water; and to diminish the scour in Sawyer's Bend by clearing Pocket Chute of similar obstructions.

I am not prepared to recommend the works proposed for re-opening Cabaret Slough, but think that the efforts in that direction should be limited to dredging a channel-way through the bar at the head of the slough, so as to aid the current in removing the lighter and less compact material of which the bottom of the slough is composed below this bar.

To improve the harbor of Saint Louis and to give it a permanent character, I am inclined, as at present informed, to regard favorably the project of substantially canalizing the river throughout the whole length of the harbor by jettees or by dikes, which would eventually extend some distance above and below Saint Louis.

The improvement and maintenance of this harbor is a subject of so much difficulty and importance that I propose to refer it to a board of engineers, the members of which have had special experience in the treatment of rivers. In the mean time I submit this report, which, in connection with those of previous dates, show the amounts required for closing Ellis's Island Channel, opening Mobile Chute, Maple Bar Slough, Packet Chute, and Cabaret Slough. Should it be deemed desirable to

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make provision for the construction of jettees or dikes, the estimate submitted in Captain Allen's report for the Cabaret Slough dikes may serve to show the cost of such works.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

OFFICE WESTERN RIVER IMPROVEMENTS,
Saint Louis, Missouri, October 2, 1871.

GENERAL: I have the honor to forward herewith the report of Captain C. J. Allen, Corps of Engineers, upon the re-opening of Cabaret Slough in the Mississippi. Captain Allen proposes to build a dike from the head of Cabaret Island 1,800 feet long, and projecting obliquely into the stream, so as to catch and deflect about one-third of the water to the eastward of Cabaret Island, to revet the head of the island to prevent scour, and also to place spur-dikes along the eastern shore of the slough to prevent the increased current from wearing it away. He also proposes to cut a channel through the slough, in order to start the water, and then relies upon the increased current and volume of water to do the balance of the work required. The method proposed to effect the object is, to my mind, the most simple and obvious which can be projected, and if carried out will, it can hardly be doubted, be successful.

The length of the dike which may be required is not so obvious. The fact that the channel through the slough is shorter than that now taken by the river through Sawyer's Bend, and consequently that the fall is greater, and that the stream flowing through it would have a greater velocity than where it now runs, is in our favor, and leads to the natural question, Why, then, is not this the channel? Is not the answer found in a remark of Captain Allen, when, in speaking of the character of the soil as found by boring, he says: "The bar at the head of the island apparently contains more gravel and was more compact than the others;" and also in the fact that the current strikes the Illinois shore *just above* the head of the slough, and is there deflected to the opposite bank, leaving an eddy, or comparatively still water, at the entrance, and consequently there is not force enough to remove a comparatively compact bar?

If, then, even a portion of the water is given the proper direction, and an opening is made through this bar, we may reasonably rely upon the current to do the rest of the work, and would have reason to hope that the desired object might be attained by even a less dike than is proposed.

Opening Cabaret Slough has been a favorite project of most engineers who have written on the harbor of Saint Louis. We find it first proposed by General Gratiot, in 1836; by Captain (now General) T. J. Cram, in 1844; and by the city-engineer in several subsequent reports. The Grand Chain Dike was evidently built to effect this object; and if Colonel Merrill is right in stating that the original intention was to build the longitudinal portion of this dike 6,000 feet long, it would seem that it was the wish of the engineer to dam the present channel and compel the whole stream to flow east of Cabaret Island; for, if we extend this dike 4,000 feet from its present terminus, or 6,000 in all from

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the bend, it would so nearly reach the head of Cabaret Island as to leave no doubt as to what was the intention. Such a course *fully carried out* of course would entirely stop the scour in Sawyer's Bend, and would in all probability remove the bar in front of the upper city-landing, the two great points aimed at. But in such an event another contingency is presented. The soil in Cabaret Slough is, if possible, more unstable than that in Sawyer's Bend, and we have good reason to anticipate that the scour here would be as great as that we are aiming to relieve. Hence, Captain Allen has provided for protecting the banks of the slough, should the channel be opened.

The estimates presented are based upon the best data obtainable, and are believed to be sufficient to cover the cost of the work; but it must not be forgotten that we are dealing with the most uncertain and treacherous of streams, and that the best of estimates are of necessity very uncertain.

Very respectfully,

W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

SAINT LOUIS, MISSOURI, *September* 8, 1871.

COLONEL: I have the honor to submit the following report relative to the survey and examinations made to ascertain the cost of re-opening Cabaret Slough, and the conclusions deduced therefrom.

In my report of the 3d of February last, upon the examination of the Mississippi River, from Alton to the mouth of the Meramec River, including the harbor of Saint Louis, I stated that, "undoubtedly, if the river could be made to take the same course it had before the Cabaret Slough was closed up, the upper portion of the harbor would attain very nearly the same condition that it had before the flood of 1851. Should this ever obtain, the Cabaret Slough would require revetment of some portion of its banks."

In April, following, I was directed to make the necessary examinations to determine the cost of re-opening the slough. With your consent, I determined to make these examinations as complete as possible, in order to set at rest all doubtful questions. The party was organized and took the field about the latter part of April, under Mr. S. E. McGregory, civil engineer, who had made the survey the preceding season. I also established four water-ganges at different points, referring their zeros to the same point, viz: the city directrix. Arrangements were made with Mr. C. Leppelmann, of Carondelet, to make a series of borings at points in the vicinity of the Chain of Rocks, and the head of Cabaret Island, as well as through the slough, to ascertain the nature and depth of the deposit above the bed-rock of the river. The party was actively engaged until about the 1st of July, when it was ordered in and the map projected. In order to make the latter clearer, and to show the approaches to the slough, portions of the map of last year's survey above the head of Chouteau Island, and below the site of the new water-works, were added.

I personally reconnoitered the river from Alton to this city several times during the progress of the examination, but was prevented by repeated absences from the city, in the discharge of the various other duties committed to me, from giving my entire attention to it. I have, however, perfect confidence in the accuracy of Mr. McGregory's measurements. Considerable changes have taken place since the survey of 1870, in the formation and movements of bars, and the abrasion of the banks. A large bar has formed at the mouth of Mobile Chute, and cutting has taken place in the west bank of the chute. The wear of the banks continues on both sides of the river from Alton to this city, more particularly opposite the mouth of the Missouri, along the whole extent of Chouteau Island, in Sawyer Bend, and in the bend above the head of Bloody Island, and below the long dike. The banks in the latter bend require some defensive work.

Although not having direct reference to the subject of re-opening Cabaret Slough, it may not be out of place for me to renew here the general recommendations contained in my last report, referring to the improvement of Alton Harbor, work at the mouth of the Missouri, the necessity of systematic observations of the river, and the closing

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of the channel behind Arsenal Island, and the revetment of a portion of its western bank. My last report contained a general description of the portion of river passed over, so that it is unnecessary to recapitulate here, the accompanying tracing giving all the information gained, from which a better idea of the changes can be obtained than from any written description.

The great extent of the abrasion in Sawyer Bend, and the existence of the bar along the northern portion of the levee front, have been causes of anxiety to the citizens of Saint Louis for the last twenty years. The nature of these evils and the causes by which they were produced having been detailed in my report of the 3d of February last, it is unnecessary to restate them here.

An estimate made in a report to the city council of Saint Louis, in 1869, placed the cost of revetting and protecting the bank in Sawyer Bend at $134,670.10 for 10,000 feet. The whole length of shore needing revetment is, in my opinion, 2,200 feet. At the rate given above, this would cost $379,769.68. My observations have convinced me that this estimate is too small, particularly in the amount of rock estimated for the longitudinal retaining dike. I should increase the entire estimate by 50 per cent., bringing it up to $569,654.52. Less than this would not, in my judgment, suffice for the revetment of the banks in Sawyer Bend.

Even since the closing up of Cabaret Slough it has been a favorite project to force the water through it again, so as to re-establish the order of things that existed before the flood of 1851, and the city-engineers of Saint Louis have made a number of reports upon the subject in concurrence with the general idea. These recommendations culminated in the erection by the city, in 1866 to 1868, of a stone dike upon the chain of rock on the Missouri side, and above the head of the slough. The cost of this dike and its effects are detailed in my report of February 3. The position of the dike is, in my opinion, good; but as to its shape I cannot agree with the projectors. A curved dike extending along the reef, from a point about one-third its length below the head of the reef, terminating at the lowest point of the original longitudinal portion, concavity up-stream, would seem preferable to the present plan, or even to an oblique rectilinear dike, which latter I consider as better adapted to the deflection of the water than the one now in position. The dike is entirely too low to intercept enough of the discharge at mean stages, and at higher stages the river flows over it without any more effect being observable than would be expected from a low, drowned dam.

Water, in order to be deflected, must impinge well upon the deflecting object. The main currents, at low water, pass far to the east of the dike. This objection would apply to any plan of dike adopted for the chain, on account of the convexity of the shore above it. A dike upon the chain, then, would only be expected to exert an influence in favor of scouring the slough at mean and higher stages of water.

I made a personal examination of this locality in June last, when the surface of the river at the foot of Walnut street was 20.69 feet below the city directrix. There was then about one foot of water flowing over the perpendicular portion of the dike. This portion, having been erected upon the rocky reef, is nearly in the same condition as when built. The longitudinal portion, originally 2,000 feet, has settled badly in many places, and 420 feet at the lower end have sunk nearly from sight. Were the dike raised to the height of 14 feet above ordinary low water, it would produce more effect, although, even then, it would not be sufficient *alone* to produce the required discharge through the slough. In addition to the tendency of the water to "draw" around its lower end, it could not, from its position, intercept the return-currents from the lower portion of Chouteau Island. The currents, wearing away concavities in the loose, soft soil of this island, are deflected westwardly in the direction of the last tangent to the curve, and, uniting with the other currents, flow partly through Pocket Chute, and mainly through Sawyer Bend, grinding the banks of the latter.

It seems clear that if a sufficient portion of the river could be made to pass through Cabaret Slough, the effect would be two-fold, viz, to assist in washing away the bar along the wharf northern, and to mitigate, by the decreased discharge through Sawyer Bend, the abrasion of the banks of the latter. Whatever quantity of water may be abstracted from the discharge through Sawyer Bend must reduce the scouring force of the current. While the height of water-surface in the bend will not be lowered by a decrease of the discharge, the velocity, which is a factor of the volume, will be decreased at first. The decrease of velocity will, however, increase the depositing power of the stream, and the result may be that the cross-section in the bend will be reduced until the velocity rises to its original value, when the grinding process will go on as before; but, it may be said that the deposition of material will protect the lower *strata* of the banks from wash. Again, it is not possible to state, with certainty, that the river in this portion may not seek for itself a new channel between Cabaret Island and the Missouri shore, relieving the banks of the latter still more, at low water, from scour. No diminution of velocity can, however, prevent the caving of the banks in some measure. Nothing but a perfect revetment, or entire shifting of the bed of the river, will entirely prevent abrasion of the banks in the bend.

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The effect of the discharge of a sufficient quantity of water through the slough would be to throw the resultant of its current and the diminished current through the Sawyer Bend, toward the west, and assist in removing the bar that now renders the approach to the wharf northern, at low and mean stage, difficult.

The dikes, from opposite Bissell's Point to the head of Bloody Island, have been the means of diminishing the size of this bar, but still not enough. If nothing is done to re-open Cabaret Slough these dikes should all be extended and raised to the height recommended by Colonel Merrill, viz, 14 feet above low water; in any event, the Long Dike should be extended and raised, in order to effect the removal of the bar between the head of Bloody Island and the city levee opposite. Even if Cabaret Slough is re-opened the raising of Bischoff's Dike will materially aid the system.

All hydraulic works in large streams are more or less experimental, and in a stream the size of the Mississippi below the Missouri, with movable banks and constantly shifting bottom, the elements of uncertainty are greatly multiplied.

The nature of the American Bottom, through which the river flows, is such that it seems almost out of the power of man to control the eccentricities of the stream. Of one thing I am certain, the improvement of the navigation of the river and the protection of the banks can only be maintained by a constant fight against its encroachments. While it is certain that defensive works can be effected, it is equally certain that the safety of the work will be jeopardized by every succeeding flood, and that either additional funds may be needed to repair it or to create new works in its vicinity.

My opinion is that Cabaret Slough can be re-opened, but whether it is *wisdom to undertake* it, in view of all the uncertainties that will, and cost that may, attend the *preservation* of the works, may well be questioned.

The cost of re-opening Cabaret Slough is required. In order to answer this question it will be necessary, first, to state briefly the general facts gained by the survey, and upon which my estimate is based. Measurements taken during the progress of the survey showed the slough to be 2,700 feet in width at the entrance, narrowing to 1,680 feet at its middle point, thence increasing to 2,520 feet at its foot.

	Feet.
Length of east shore	22,200
Length of west shore	19,200
Greatest width of water-way	1,260
Least width of water-way	300
Greatest depth of water	15
Least depth of water	¼

The deep water was generally found in pools or pockets; the shallow water, as might be expected, on the shoals or ridges separating the pools. The accompanying sections taken through the slough fully explain the condition of affairs.

The soundings were all referred to the mean stage of water existing during the survey, which, in the vicinity of the Chain of Rocks, was taken at 14 feet below the directrix. The slough was nearly closed up with accumulations of sand and gravel. The specimens brought up by the borings consisted of coarse and fine sand, shells, and gravel; the latter varying from one-fourth of an inch to one inch in diameter. The proportion of the latter was small,

The borings were sixteen in number. The positions of three were not plotted; the thirteen which were plotted were taken in the following places: At the head of Cabaret Island, rock was found at a depth of 52.30 feet below the surface of the water; at middle of line across head of Cabaret Slough, the sand overlaid the rock to a depth of 56.26 feet; at point near foot of Chouteau Island, rock was reached at a distance of 58 feet below the water-surface; at point opposite head of Chain of Rocks, rock was found at a depth of 37.70 feet below the directrix, and 22.70 below the water-surface. The others were taken at various points through the slough, penetrating to depths varying from 56.90 feet to 41.37 feet below the line of the directrix, without reaching rock. The materials brought up from the points near the Chain of Rocks and Chouteau Island were of the same nature as those obtained in the slough. The bar at the head of Cabaret Island apparently contained a greater proportion of gravel, and was more compact than the others. A series of current-observations taken above the head of the slough showed surface-velocities varying from 4.3 feet to 6.2 feet per second; the line of least velocity being below the dike on the Chain of Rocks, the two lines of currents terminating just above the head of the slough being respectively 5.4 feet and 5.7 feet per second. The tracing accompanying will show the directions assumed by the line of currents.

The surface of the water at the foot of Walnut street on the 22d day of April, the date of commencement of the survey, stood at 19.69 feet below the city directrix, or 14.12 feet above the lowest water-mark of 1863. The surface of water at this same station was, on the 30th of June, the date of the termination of the survey, 19.66 feet below the plane of directrix, or 14.15 feet above lowest water mark of 1863. The greatest range during this period was 21′.44, 15′.70 = 5′.74.

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A comparison of thirty-six gauge-readings between the gauge at the head of Cabaret Slough and the gauge at the new water-works gave a mean slope between the two of 3.2445 feet. The distance between the two points, measured along the channel of the slough, was found to be 27,000 feet. The distance from the gauge at the water-works, measured along Sawyer Bend Channel to a point opposite the gauge at the head of the slough, was found to be 31,200 feet. The difference of level, as ascertained on the 17th of May, between the gauge at the new water-works and a point on the Missouri shore above the head of Cabaret Slough, was 3.424 feet on a distance of 33,000 feet.

Careful levelings, taken on the 15th of June, when the river, at the foot of Walnut street, stood at 18.01 feet below the directrix, or 15.80 feet above the lowest water of 1863, showed a fall of water-surface, through the slough, of 3.06 feet upon a length of 21,600 feet. I have called it three feet. Abstracting the effect of bend-resistance, there remains (without going into details of calculation) a head sufficient to give a mean velocity of 3 feet per second for a channel of from 1,600 to 1,650 feet in width. This velocity is sufficient to remove such materials as were found in the slough.

Any additional velocity which may be gained over this, due to the head resulting from forcing more water into the slough than it naturally discharges, or would discharge if simply cleared of obstructions, will be so much gained for purposes of scour.

It remains, then, to force a body of water through the slough considerably in excess of the natural flow at mean stage of water, and, for this purpose, the most feasible plan that presents itself is to construct a deflecting dike of 1,800 feet in length at the head of Cabaret Island to intercept a sufficient portion of the water now passing to the west of the island. It is estimated that nearly one-third of the discharge of the river, at the mean stage existing during the survey, can be forced toward the slough.

To attain a velocity of discharge sufficient to scour out the obstructions, I propose to make the water-way of the slough 1,650 feet in width, measuring from the tops of the contracting dikes. The latter are indicated on the tracing, and are designed to serve two purposes, viz, to regulate the width of water-way and to protect the banks from wash. Some revetment of the banks of the slough will also be needed, as well as revetment of the head of Cabaret Island. The latter revetment should be of stone; the former, as well as the spur-dikes, of brush and stone.

The main dike at the head of the island, as laid down, will make an angle of about 38° with the direction of the observed currents near its head. This, although not the most favorable angle for deflection, is the best, under the circumstances, that can be adopted.

At first sight, it might seem that the dike, by contracting the water-way between itself and the foot of the Grand Chain Dike, would be a source of trouble to ascending steamers. I think not, provided the free discharge through the slough can be *maintained*. If, however, from any changes, in the course of years, in the river above, the slough should again fill up, the ascent of steamers through the chute between the heads of the dikes would be extremely difficult, if not impossible. The current would probably impinge upon the Missouri shore below the chain of rocks with redoubled violence.

To resume: The quantity of water drawn off through the slough will tend to proportion the discharge to the area between the heads of the dikes so as to keep the velocity sensibly what it was before; in addition, any increased head will soon cause the bottom to scour out, until the requisite area of cross-section is obtained. This scouring will render it very difficult to construct the head of the dike; in fact, the scour will increase with every foot of its progress from the head of the island. Success can only be obtained by constantly throwing in stone, which should be in pieces of not less than 25 to 30 pounds weight, and the lower layers of the head should be composed of stones of a cubic foot in contents, and over. Smaller stones should be thrown in along the east face of the dike. Stone is recommended for this dike, as experience has proven it to be the best material that can be used in this locality for the construction of dikes when subjected to strong scour.

An estimate of the quantity of stone required for the erection of a dike upon the material of which the bed of this portion of the river is composed, overlying the rock to a depth of 50 feet and upward, is, more or less, a matter of conjecture. The dike will continue to settle until it reaches a point below the effects of scour; it is not improbable that this point will be, for the head of the dike, the bed-rock itself. From a comparison of the cost of other dikes, I have been enabled to submit an estimate which will, I think, meet the cost of the dike now under consideration. I would make the top of the main dike 14 feet above the low water of November, 1870, and the spur-dikes about the same height. The heights and locations of the latter may be modified as the work proceeds, the locations of the dikes on the tracing being merely approximations. The reaches of bank between the dikes, as well as the angles between the latter and the shore, should be further protected by planting willows, for which an estimate is made. The reaches can be still further protected by loose stones placed along the foot of the slopes, about a foot apart. These, together with the accumulation of sedi-

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ment below the dikes from the subsidence of high water, and the effects of the dikes themselves, will sufficiently protect the banks, which have, on the eastern shore, suffered considerably from abrasion during the last thirty years. To assist the flow of water through the slough until the current gets its "*train*" will require the use of an Osgood dredge to open up a thread for the current to follow. After this is once opened, it can be kept so by the use of the Long scraper until the flow is fairly established. The material raised by the dredge can be utilized by depositing it in the angles below the dikes, and incorporating a portion of it with the structures themselves.

No estimate has been made for the protection of the lower portion of Chouteau Island, or the portion of the bank of the slough immediately below it, as it would be an advantage to the work were these portions to wash away for a depth of a few hundred feet.

I estimate that it will require three years to get the dike fairly settled and complete the entire work. To lay down any programme in advance would be impossible, further than to say that the work in the slough should commence at the head and be carried on toward the foot.

If the work is undertaken, I regard it as important to have the entire amount of the estimate available at the outset.

In the accompanying estimate it will be noticed that I have added 25 per cent. to price of stone delivered in dikes and revetment in the slough. This is to allow for extra handling requisite.

Accompanying this report are two tracings—one showing the river from the mouth of the Missouri to the river Des Peres; the other an outline map of the immediate vicinity of Cabaret Slough, showing positions of dikes, &c.; both on a scale of 1 inch to 600 feet.

Estimate of cost for re-opening Cabaret Slough.

For dike, 1,800 feet long:		
98,000 cubic yards of stone, at $2, delivered in dike		$196,000 00
Construction of spur-dikes in slough:		
8,613 cords of brush, at $2.25 per cord, delivered in dikes		19,379 25
8,613 cubic yards of stone, at $2.50 yer yard, delivered in dikes		21,532 50
Revetments:		
Revetting 3,000 linear feet of bank at head of Cabaret Island, 22,000 cubic yards of earth are to be removed and slopes graded, at 35 cents		7,700 00
870 squares of riprapping, at $5		4,350 00
2,000 cubic yards of stone for longitudinal retaining-dike, at $2		4,000 00
Revetment of 2,500 feet:		
709 cords of brush, at $2.25, delivered in revetment		1,595 25
709 cubic yards of stone, at $2.50, delivered in revetment		1,772 50
Revetment of east shore of island, opposite middle point of slough:		
422 cords of brush, at $2.25, delivered in revetment		949 50
422 cubic yards of stone, at $2.50, delivered in revetment		1,055 00
Planting and cultivating willows		5,000 00
Dredging channel in slough:		
250 days' work of Osgood dredge, at $90 per day		22,500 00
100 days' service of Long scraper, at $100 per day		10,000 00
1 small steamer		10,000 00
Cost of running same 540 days, at $40 per day		21,600 00
Engineering and superintendence:		
First year	$12,960 00	
Second year	10,440 00	
Third year	4,680 00	
		28,080 00
Add for contingencies 15 per cent. of all		53,327 10
Estimate		408,841 10

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Lieutenant-Colonel W. F. RAYNOLDS,
Corps of Engineers, U. S. A., Saint Louis, Missouri.

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MISSISSIPPI RIVER OPPOSITE THE MOUTH OF THE MISSOURI.

OFFICE WESTERN RIVER IMPROVEMENTS,
Saint Louis, Missouri, February 8, 1872.

GENERAL: In compliance with your instructions of the 13th ultimo, I have had an examination made of the Mississippi River opposite the mouth of the Missouri, and I have the honor to forward herewith the report of Captain C. J. Allen, to whom the immediate charge of the examination was intrusted. The abrasion of the bank at this point has been going on for years, and there does not seem to be any new developments in regard to it at this time. The rate of progress cannot be foretold, and seems to follow no law other than that it is more rapid when the Missouri is high and the Mississippi low, for the reason that the resultant of the streams is then thrown with greater force against it.

The sketch forwarded herewith shows the shore-line as it was in 1813, (laid down from the land-surveys,) in a dotted black line; the dotted red line shows where it was found by Major Merrill in 1868; the full red line is where it was found at the time of our survey in 1870; and the full black line shows it as it was on the 25th ultimo.

The bank at the end of the Madison County Railroad was partially revetted some years since, which for a time seems to have checked the action of the water. The revetment was intact at the time of Major Merrill's survey, but now is the pile of stone shown on the sketch at A, near the western bank, the entire channel being to the east of it. Since the river cut a channel around this revetment, the erosion has been rapid. The whole change, measured on the line of the prolongation of the Madison County Railroad since 1813, is about 2,600 feet; since 1868, Merrill's survey, 950 feet; since October, 1871, to January, 1872, 400 feet.

The large sand-bar forming the eastern portion of Mobile Island seems to have moved eastward at about the same rate as the opposite bank of the stream.

Last season the Missouri River seemed disposed to resume its old channel through Mobile Chute, and it was plain that if this could be effected the erosion of the opposite Illinois shore would be materially lessened if not checked entirely. A small amount ($25,000) was asked for, for the purpose of aiding the river, in hopes of gaining this object.

The Missouri is at present very low, yet still a small quantity of water takes the desired course through the main channel, rebounds from the right bank just above the head of the chute, and then crosses the river diagonally, showing no disposition to take the course we desire it should. It is impossible to predict what will be the condition of affairs when a rise occurs, but the present indications are that a much larger sum will be required to effect the object than was thought necessary last season. I am still of the opinion that the deflection of a large portion of the waters of the Missouri through this channel is the most desirable method of making the proposed improvement, not only because it would afford relief immediately opposite where the channels of the two streams now meet, but because it would shorten by several miles the route into the Missouri, and give us reason to hope for important favorable changes in the channel of the Mississippi, possibly as far down as the city limits.

As matters now stand, the waters of the Missouri could not probably be deflected into Mobile Chute without running out a dike from the head of Mobile Island for a distance of 1,500 feet, which would cost, at

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$50 per running foot, $75,000, in addition to the $25,000 estimated last season for removing the snags and other obstructions which now obstruct the channel, or, in all, $100,000.

The plan of protecting the Illinois shore, (which seems to be contemplated in your letter of instruction,) as proposed by Captain Allen, would certainly be effectual in preventing further erosion, and the cost of the work by the two methods of jettees and continuous revetments has been estimated with care, and is as nearly correct as estimates can be made for such works.

Though not contemplated in your letter of instructions, I take this occasion to call your attention to the condition of the river immediately opposite this city, as, from the frequent mention which has been made in our city papers of this point during the past two months, I think it possible that the parties who called the attention of the Bureau to this matter had this locality in view. Sketch B, forwarded herewith, shows a section of the river immediately opposite the city, and above the site of the bridge now under construction.

During the recent intensely cold weather the ice lodged on the shoal opposite the old water-works and ferry-landing, thus forcing the water toward the Illinois shore and around the head of Long Dike at U, and against the bank near the Chicago, Alton and Saint Louis Railroad, causing it to wear away very rapidly. The action has to a considerable extent diminished, but, to prevent future trouble, I understand that the city authorities propose the extension of Long Dike some 600 feet, so as to confine the channel to a width of about 1,600 feet, or about that of the water-way under the bridge.

The improvement of the mouth of the Missouri River should be considered as part of a general scheme for the improvement of the harbor of Saint Louis, and any plan for the latter purpose should take into view the interests of the whole city, at least as far down as the mouth of the Des Peres River, if not to include the Government reservation at Jefferson Barracks, and down to the mouth of the Meramec. To my knowledge, no general plan has ever been submitted, but when we remember the large estimates which have been submitted for different localities, and the fact that no estimates have been made for the lower half of this harbor, where improvements are even now called for, it is but too evident that a large amount will be required for the entire improvement. I am satisfied that the true interests of the Government, of commerce, and of this city demand that an appropriation of not less than $500,000 should be made at once, and the appropriation so worded as not to confine the expenditure to any one locality, and that a board of officers, having the largest experience in this kind of duty, should be convened for the purpose of taking the whole subject into consideration, who should decide upon the best method of expending the amount appropriated, and also of making all the improvements demanded, and that when the work is once decided on, it should be pushed to its completion with the utmost vigor.

Very respectfully,

W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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SAINT LOUIS, MISSOURI, *February* 7, 1872.

COLONEL: As directed by you, I have made an examination of the Illinois shore opposite the mouth of the Missouri. Measurements taken show that much change has taken place since the survey made in the fall of 1870.

The current of the Missouri seems to be bearing more toward Missouri Point and the foot of Maple Island, and that of the Mississippi, after it leaves the foot of Ellis Point opposite Alton, bears strongly toward the Missouri shore, wearing away a deep concavity in the latter; thence, rebounding toward the Illinois shore, it has cut away more than one-third of Maple Island, and, finally, uniting with the current of the Missouri, the two bear with full force upon the Illinois shore in Missouri Bend.

The bend has suffered an average abrasion of 250 feet in depth upon a length of 20,000 feet since October, 1870. In one place, at the end of the Madison County Railroad embankment, the bank has been cut away to the depth of 950 feet since 1868.

Fears have been entertained for a number of years that the river would break through its banks, and, finding its way into the valleys of Long Lake and Cahokia Creek, pass far to the east of Saint Louis, completely shutting the city off from the river.

In my report to you of the 3d of February last, upon the mouth of the Missouri, I stated that I apprehended no immediate danger to the city from this cause, and the results of my recent examinations have only confirmed the opinion then expressed. As I have already described this locality in the report referred to, it would only be a repetition of words to describe it again.

The destruction to property from this abrasion is great, and if some protection is not afforded the banks, numbers of farms and other property will be destroyed, unless, from causes that cannot be foreseen, the action of the currents should be stayed.

A great deal has been written upon this subject, and a variety of plans suggested to meet the difficulty, the majority of them based upon the idea of turning the course of the Missouri. The effects of such measures upon rivers like the Missouri and Lower Mississippi are always uncertain, and it would seem best, in my opinion, where a choice is left the engineer, to protect the banks wherever necessary and not interfere with the flow of the stream.

An exception, however, exists in the case in which an inclination is observed upon the part of the stream to take the course we wish it to pursue. It is well, then, to assist it. Upon this principle it was suggested, in my last report to you, to clear the obstructions from Mobile Chute. But the conditions of last year upon these rivers are not the conditions of this year. The Missouri current seems now to be bearing away from the head of Mobile Chute. A flood, however, may bring it back.

The only way that seems clear to me to effectually prevent further abrasion in Missouri Bend is, to protect the banks either by means of jettees or with a continuous revetment. The former, although cheaper at first than the latter, are open to many objections. It is necessary to carry them up high enough to protect the banks at all stages of water—in this locality as high as the banks themselves; and they should be carried out far enough, at this level, to protect the reaches of shore between them from the action of the eddies. They are, moreover, subject to heavy scour at their heads and to the injurious action of the water as it flows over them; particularly so at the junction of the shore and jettee. What ratio exists between the length of jettee and the length of bank it protects is not easily stated. I have seen it placed as high as one linear foot of jettee to five linear feet of bank. In the case of a jettee built in the Missouri River at Saint Charles, it is claimed that the length of shore protected was about four times the length of jettee. It depends mainly upon the location of the jettee.

A continuous revetment, although more expensive, presents better chances of permanency, and would insure more thorough protection to the banks.

The difficulty of founding upon such soil as forms the beds of the Missouri and Mississippi Rivers at their junction is well known to all who have given the subject any study.

The usual practice for the protection and maintenance of the banks in the harbor of Saint Louis, (where the bed of the river is of the same nature as at the mouth of the Missouri,) and which has given the best results, is to build a longitudinal retaining-dike of loose stone at the foot of the scarp, and then grade and riprap the bank. This method requires a great quantity of stone, particularly where the dike is subject to scour; the stone disappears almost as rapidly as thrown in. The only way is to continue to throw on stone until the mass sinks to a firm surface, or to a point below the effect of scour.

The expense of applying this method to the bend opposite the mouth of the Missouri would be too great to warrant its adoption.

I believe that, in building a revetment at the foot of the scarp in Missouri Bend, an equally good and much more economical plan would be to sink rafts or aprons of brush, weighted down with stone; the rafts to be built upon light floating frame-work of hoop-poles, or small saplings; the stone in pieces of thirty pound weight and up-

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ward. A large quantity of brush and stone would be required. The former can be obtained within a radius of ten miles, and the quarries of Grafton, Alton, and Saint Louis can furnish the stone. Brush fascines, and willow panniers filled with stone, could also be used to advantage in connection with the brush-aprons.

The revetment or retaining-dike should be firmly settled, and carried up to the surface of low water. From this point the bank should be graded to a slope of 1 upon 1½, and covered for half the distance up with a layer of 6-inch stone, placed with the rough edge down; the remaining distance to be covered with a layer of 4-inch stone, similarly placed. The top of the bank should be lightly strewn with 3-inch stone for a width of 5 or 6 feet. The stone being simply laid upon the surface will, in the event of any slight wash beneath it, settle and keep the protection good.

It is not easy to estimate the cost of the brush and stone revetment; but after careful consideration, I would not place it lower than $15.50 per linear foot of bank to be revetted. This is independent of the grading and riprapping, or covering. It is also difficult to estimate the cost of jettees with any degree of certainty. I would place their cost at $50 per linear foot of jettee. Assuming that, if properly located, 1 linear foot will protect 4 feet of shore, we have for this method $12.50 per linear foot of bank to be protected.

If the work is undertaken, it will probably be necessary to carry it for some distance above and below the present limits of erosion. On this account, and the probability of further wear, I have estimated for the protection of 22,000 feet of bank.

If it is undertaken to revet the bank continuously, care must be taken not to allow the current to cut in behind the line of dike or revetment, as this would simply result in shifting the line of scarp.

It would be necessary to commence the work of grading and riprapping as soon as the revetment could be carried high enough to enable it to be done. The average height of bank above low water is 25 feet.

Estimate for protection by means of jettees.

22,000 linear feet of bank, at $12.50	$275,000
Add for engineering and contingencies 15 per cent	41,250
Total	316,250

Estimate for protection of bank by means of continuous revetment, grading, &c.

22,000 linear feet of brush and stone revetment, at $15.50	$341,000 00
381,944 cubic yards of earth excavation and grading, at 30 cents	114,583 20
9,187 cubic yards of 6-inch stone covering, at $2	18,374 00
6,067 cubic yards of 4-inch stone covering, at $2	12,134 00
1,000 cubic yards of 3-inch stone for top of bank, at $2	2,000 00
	488,091 20
Add for engineering and contingencies 15 per cent	73,213 68
Total	561,304 88

It will be seen that either plan will be very expensive.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Lieutenant-Colonel W. F. RAYNOLDS,
U. S. Corps of Engineers, Saint Louis, Mo.

I 10.

MISSISSIPPI RIVER, BETWEEN THE MOUTH OF THE ILLINOIS AND THE MOUTH OF THE MERAMEC.

Report of a board of engineers assembled by virtue of the following order:

[Special Orders No. 20.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 7, 1872.

I. A board of engineers, to consist of Lieutenant-Colonel John Newton, Corps of Engineers; Lieutenant-Colonel W. F. Raynolds, Corps of Engineers; Major G. K.

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Warren, Corps of Engineers; Major W. E. Merrill, Corps of Engineers; Captain C. J. Allen, Corps of Engineers, will assemble at Saint Louis, Missouri, on the 19th instant, or as soon thereafter as practicable, to examine and report upon such questions connected with the harbors of Saint Louis, Missouri, and Alton, Illinois, and with the banks of the Mississippi, as shall be placed before it by further instructions from these headquarters.

The junior member will record the proceedings.

* * * * * *

By command of Brigadier-General Humphreys:

THOS. LINCOLN CASEY,
Major of Engineers.

The following instructions were placed before the board by the senior officer:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 7, 1872.

COLONEL: The board of engineers constituted by Special Orders 20, Headquarters Corps of Engineers, February 7, 1872, to convene at Saint Louis, Missouri, February 19, of which you are the senior member, will examine and report upon the present condition of the Mississippi River between Alton and the mouth of the Meramec, with a view to the preparations of plans, with estimates of cost, for the improvement and maintenance of the harbors of Saint Louis and Alton, and also for the prevention of the erosion of the banks of the river.

The board will examine all the maps and projects that have been heretofore prepared, and thoroughly investigate the subject, giving their views and recommendations as to the proper steps to be taken to secure the desired improvements and maintenance, and report a project or projects, with estimates of probable cost, for the permanent improvement and maintenance of the harbors named, and which will secure a permanence to the channel-way of the river between Alton and the mouth of the Meramec.

The board will designate the works intended to afford prompt relief at such points as may seem to require it.

Colonel Raynolds will be directed to furnish the board with all reports, maps, and other information in his possession bearing upon the subject, and will be authorized to employ his assistants in procuring any further information they may desire.

By command of Brigadier-General Humphreys:

JNO. G. PARKE,
Major of Engineers.

Lieutenant-Colonel JOHN NEWTON,
Corps of Engineers, New York City.

In compliance with the above instructions, the board examined all the plans and projects that have come to their knowledge, bearing upon the river and its improvement within the limits specified, and also consulted with the city authorities of Saint Louis and Alton, with civil engineers, and others who were familiar with the requirements of commerce and the peculiarities of the stream upon which they are required to report.

They also made a personal examination of the river from Alton to the mouth of the Meramec.

The section of river from Alton to Lower Saint Louis has been described, more or less in detail, in the various reports that have been submitted, viz: in Captain Lee's report of 1837, Captain Cram's report of 1844, Colonel Merrill's report to the city of Saint Louis in 1869, General Warren's report on Alton Harbor and vicinity in 1868, and General Raynolds's report, upon the entire portion under consideration, of February, 1871.

A brief description only is therefore necessary to aid in the present discussion of the subjects.

The general course of the river from the upper part of Alton to the junction of the Missouri and Mississippi is east of south, the distance, measured along the usual channel of the river, being nearly five miles. Thence, to the mouth of the Meramec, the course is nearly south; the

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distance, measured along the channel of the river as surveyed in 1870, is thirty-seven miles; the whole distance being about forty-two miles.

At the upper part of Alton the rocky escarpment known as the Illinois Bluffs begins, bordering and rising above the surface of the river to the height of 200 to 250 feet, and continuing up to the mouth of the Illinois.

The opposite shore, in Missouri, is alluvial. Ellis Island lies in front of the lower part of the town, and separated from the Missouri shore by a slough averaging 1,000 feet in width.

The east bank of the Mississippi from Alton all the way to the mouth of the Meramec, and below, is alluvial, subject to overflow at high stages of the river, and, where not artificially protected, everywhere liable to erosion. This low land is from five to eight miles in width, and forms part of what is called the "American Bottom." It has been protected from overflow, in some portions, by levees, and mostly cleared of forests, and contains a number of swales and lakes. All the railroads approaching Saint Louis from the eastward are located upon it.

On the west bank the shore is alluvial from Alton to the Chain of Rocks, a distance of eleven and a half miles by the course of the river. Within this space the Missouri makes its junction with the Mississippi, the currents of the two rivers meeting nearly at a right angle, causing a violent action against the Illinois shore and seriously eroding it. The point of land between the two rivers is wooded and subject to overflow. At the Chain of Rocks, which extends about one mile along the west bank, an extensive wing-dam has been erected by the city of Saint Louis. This dam will be mentioned again further on.

The west banks are alluvial from the Chain of Rocks along Sawyer Bend down to Saint Louis, and are being rapidly eroded.

At the foot of Sawyer Bend the Saint Louis water-works are located. From this point down to the Meramec the shores are either artificially protected from erosion or formed by the stratified rocks so as to be permanent, excepting about one-half mile at the mouth of the Des Pères, an unimportant stream, forming the present southern boundary of the city.

Between Alton and the Meramec, the river contains a number of alluvial islands, unprotected by any sort of revetment and subject to erosion, and many sand-bars more or less dry, according to the stage of the river.

The islands occur in the following order: Ellis Island, opposite Alton, already mentioned; Maple Island, below it, near the middle of the stream; Mobile Island, on west bank, immediately below the mouth of the Missouri; Chouteau Island, near the east bank; Wilson's Island, near west bank, immediately opposite; Cabaret Island, near east bank, immediately below Chouteau Island and below the Chain of Rocks; Arsenal Island, near the middle of the river, below Bloody Island, or East Saint Louis; and Carroll's Island, near the east bank, below Jefferson Barracks. These islands are, with the exception of Chouteau Island, all separated from the main shores by sloughs. Chouteau Island Slough has been closed by a high dike. What was Bloody Island, opposite Saint Louis, is now East Saint Louis, the island having been connected with the main shore by a high dike or causeway. To the west of Cabaret Island is a small alluvial island, no name, between which and Cabaret Island is the channel called Pocket Chute.

The different projects that have been submitted will be mentioned in their order, commencing at the one highest up the river.

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A CANAL TO CONNECT THE MISSOURI AND MISSISSIPPI RIVERS AT PORTAGE DES SIOUX.

It has been proposed to turn the Missouri into the Mississippi about eleven miles above their present junction, with the view of permitting the superior force of the Missouri to expend its strength against the rocky shore of the eastern bank of the Mississippi opposite the proposed new junction; and it has been claimed that this would effectually remedy all the existing and prospective evils as far down as Saint Louis.

The board would simply refer to the fact that the difference in level between the surfaces of the two streams at the ends of this proposed canal, when the Mississippi was 4 feet above low water and the Missouri at low water, was, according to the survey made in 1843, 7.3 feet, and that the soil through which the proposed canal would run is the light alluvial deposit common to the banks of the Missouri and Lower Mississippi. In their opinion a canal with this fall, through such a soil, carrying the volume of water in the Missouri, would set in operation forces the result of which cannot be foretold; it can neither be predicted what course the stream would take below the new junction, nor what would be the expense of confining the stream to the new *artificial* channel and of *preserving any desired course* below. They therefore dismiss the further consideration of this project.

HARBOR OF ALTON.

Ellis Island and the bars at its head divide the Mississippi River here into two channels, thus aiding in the formation of a bar along the city-landing, which seriously interferes with commerce. The extent of the bar varies in different years and at different seasons, but it is at all times an obstruction which the wants of the city of Alton require should be removed. To effect this but one method has been proposed, namely, the very obvious one of closing the channel to the west of Ellis Island and throwing all the water through the eastern or harbor channel. The board believe this should be done, and would class this improvement as one demanding immediate attention.

Considerable difference of opinion exists as to whether the proposed dike for closing the channel should be only high enough to turn the water at a given stage, (say 6 feet above ordinary low water,) or if it should be carried up above high-water mark. In the latter case, it would serve as a roadway and be of immense value to the inhabitants of both sides of the river.

Several estimates for this work have been submitted, varying in amount from $15,000 for a low dike, to $112,000 for a high dike. The width and depth of the channel have increased since the first-named estimate was made, and the board do not think that this sum would now erect a dam of sufficient stability and height to accomplish the desired object. Basing their opinions on the cost of the dam erected by the city of Saint Louis to close the channel east of Bloody Island, which cost about $105,000, they would estimate the cost of a low dike at $40,000, and a high dike at $75,000. The estimates include a sum necessary to close the chute between the head of Ellis Island and the small island, or tow-head, immediately above it, to transfer the wash from the back-water—produced by the proposed dike—from the head of Ellis Island to the head of the small island, which is of little value.

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THE EROSION OPPOSITE THE MOUTH OF THE MISSOURI.

The current of the Missouri, as before stated, strikes that of the Mississippi nearly at a right angle, forcing the water of the latter against the Illinois shore, causing it to wear away rapidly.

The rate of this movement has been as follows: since 1868, 450 feet average depth of erosion, and since 1813, 4,500 feet.

In 1868, a revetment at the end of the Madison County Railroad embankment was standing as a pier, or abutment, some 300 feet beyond the general curve of the bank, forming a landing for steamers. Since then, the stream has cut through the tongue of land connecting the revetment and line of shore. There was an immediate receding of the shore-line of several hundred feet, and what was the revetment is now a pile of stone on the edge of the Mobile Island Bar, and distant 950 feet from the present Illinois shore.

The idea that there is danger of the Mississippi River changing its course at this point, so as to flow through the valley of Long Lake, thus leaving the city of Saint Louis some miles from the river, has been a source of alarm, in the minds of many, for years, but the board does not find that it has been entertained in any official report, excepting that made by Captain (now General) Cram in 1844. The board cannot imagine that there are valid grounds for apprehension on this point. The head of the swale known as Long Lake is some 8,000 feet beyond the lowest point where the erosion is going on. A high-water levee is already built, which is intended to prevent the flow of water, during floods, in that direction, and, even if the river should reach the swale, the growth of trees and underbrush would so impede its progress as to prevent its forming any considerable channel.

The erosion is destroying land worth, perhaps, $100 per acre, and after the abrasion has progressed some 1,300 feet farther the Chicago and Alton Railroad-track will be in danger; but when that time comes, the railroad will afford facilities for arresting the encroachment, and the corporation will doubtless protect its own interests. The proposition to prevent, or at least lessen, the action of the river at this point, by re-opening Mobile Chute, is worthy of consideration, and the board would recommend that the snags and other obstructions, which now obstruct the flow of water through that channel, should be removed by the snag-boats now employed on the rivers.

If it is proposed to stop the erosion by revetting the banks, or by jettees, over four miles of the bank will require protection, which will probably cost, for the first case, $500,000, and for the second, from $300,000 to $400,000.

From the mouth of the Missouri to the Chain of Rocks (or the head of Cabaret Island opposite) the river requires no special attention at present. At this latter point, during high water, the river is divided by Cabaret Island into two channels, the western passing along Sawyer Bend, the eastern through Cabaret Slough. During ordinary low stages, very little water passes through the slough, though it is considerably the shorter route. At lowest stages the slough is dry. For years the project of diverting a portion or all of the river, at all stages, through Cabaret Slough, for the purpose of removing the extensive bar along the northern wharf of Saint Louis, has had its advocates, and, to effect this, the city built what is known as the Grand Chain Dike, a structure running out from the shore on the rock foundation for 1,400 feet, then turning nearly at a right angle down stream for 2,000 feet.

Several hundred feet of the lower portion have disappeared by sink-

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ing; the rest is in a fair state of preservation. The effect of this structure has been just the reverse of what was intended.

The dike, when not submerged, serves as a partial dam, causing the water to circle round the end of the longitudinal portion and impinge upon the shore below. At medium and high stages the river flows over the dike without any more effect being produced than would be expected from a low submerged dam. As it is, it produces no effect towards turning any portion of the river into Cabaret Slough.

Aside from the serious loss of property, rendered valuable by its proximity to the city, by abrasion of the banks, the great reason for doing something to limit the action of the river in this locality is to protect the works which supply the city of Saint Louis with water, which stand on the western bank of the river just below the foot of Cabaret Island, and which are in danger of being destroyed if the action continues.

A choice must be made between two methods of effecting the desired object: first, to protect the banks in Sawyer Bend and preserve the river as it now is; second, to deflect a portion or all of the water through Cabaret Slough. The board prefer the former for the reasons that they think it best to make as little change in the regimen of the river as practicable, not shortening it, as the change into the Cabaret Slough might do. Besides the expense of opening Cabaret Slough, if it is practicable to do so, we should have the probable cost of maintaining the flow through the slough and the protection of its banks, which would be an imperative necessity if the entire volume of the river, or a large proportion of it, were forced through the channel. The protection of the banks in Sawyer Bend is a definite work, giving definite results.

The board are of the opinion that the protection of two miles of the lower portion of the bend will be all that is required for the present, and the work they would class among those requiring immediate attention.

The cost of protecting the banks is a difficult matter to reach with certainty. Estimates have been submitted by the city engineer of Saint Louis for revetting and protecting this bend, (based upon the cost of similar work done by him on the Missouri River,) at a cost of $33,000 per mile. As a practical engineer his opinion is entitled to full respect; yet, in view of the fact that the depth of scour and cost of similar works differ greatly, according to locality, in the harbor of Saint Louis, the board do not feel certain enough in the matter of cost to accept it for this particular point or to entirely reject it. After full consideration of the fate of numerous structures in the harbor, the board would not place the estimated cost of this proposed work at a lower rate than that given in Colonel Merrill's report to the city of Saint Louis in 1869, viz, $71,105.81 per mile. They wish distinctly to state their belief that, although the effect of the work if completed is definite, nothing but an actual test will determine the cost of construction.

HARBOR OF SAINT LOUIS.

The magnitude of the interests of this wealthy and rapidly growing city will ultimately demand that the river, throughout the entire length of the thirteen miles of city front, be made to flow in a permanent channel, having stable banks. The outcropping rock in portions of the city front and the general pavement of the levee furnish one of the banks already at hand; the opposite shore (with some comparatively small exceptions) must be formed. To effect this, the city and private corporations have already commenced a series of dikes from the Illinois shore, intended to confine the river to a definite channel. The upper

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dike, known as Bischoff's, is 1,390 feet long, and leaves a channel-way between it and the city front opposite of 1,440 feet at ordinary stage of water. Below this are two short dikes, known as the Upper and Lower Venice Dikes, 120 feet and 387 feet in length, respectively; 2,170 feet below the latter is the Long Dike, 1,360 feet long, the end of which is 2,390 feet from the opposite (or city) front. Below the Long Dike is a large indentation, which suffered considerable erosion from the effects of an ice-gorge on the sand-bars in front of the Saint Louis wharf during the past winter. Then comes what was once Bloody Island, where are the railroad-depots, ferry-landings, &c. The western face of this island is the East Saint Louis levee, or stone pavement, upon which almost all the business on that side of the river is done. The distance of the foot of this levee, at ordinary stage of water, from the foot of the city levee opposite, is 1,800 feet at the elevator, and 1,550 feet at the Pittsburgh Coal-Dike, according to survey of 1870.

Near the foot of Bloody Island is the eastern terminus of the new bridge now under construction. The distance between abutments is 1,582.36 feet at low water, and the two piers still further contract the channel 78.28 feet at the same stage of river. Six thousand two hundred feet below the bridge is the Pittsburgh Coal-Dike, a structure above all known high water, excepting the great floods of 1844 and 1855. It is built of sand faced with stone, the end being protected by stone revetment, formed by throwing in stone until stability was found, and on the top of this riprapping a heavy, dry wall has been carried up to the top of the embankment. The protection of the end of this dike, we are informed by the president of the company, cost over $100,000. Both above and below the Pittsburgh Dike a large quantity of land has formed. Between the end of the dike and the opposite shore is a channel-way of 1,550 feet.

On the low land, 13,000 feet below the Pittsburgh Coal-Dike, are the remains of a low dike built by the city, and near it is a low causeway built for a ferry-landing. Just below these dikes is the head of Arsenal Island, which divides the Mississippi River into two not very unequal channels, the eastern of which is known as Cahokia Bend, and was formerly the main channel. Below Arsenal Island the east bank of the river is a low sand-bar to opposite the river Des Pères—the lower limits of the city.

The board believe that the ultimate demands of commerce will require that, within the limits above specified, the eastern bank of the river will have to be brought to a line parallel, or nearly so, to the opposite city levee, and at a distance from it at low water of not over twelve or fifteen hundred feet, and rendered permanent throughout the entire distance. The present demands are that, within the upper portion, namely, from Bischoff's Dike down to the East Saint Louis levee, the channel of the river should be confined within the limits specified. To do this, the board recommend the raising and extension of the two Venice Dikes and the Long Dike, which it is estimated will cost $171,586, to which 15 per cent. should be added for engineering and contingencies, bringing it up to $197,323.90.

The board think it possible that an additional dike will be required between Long Dike and the head of Bloody Island, but they believe it best to wait and see if the large indentation will not be at least partially filled by sediment from the river before building it.

The board believe that, when these dikes shall have been built as proposed, the demands of business will soon cause the riparian owners

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to fill in between them, and to connect the ends of the dikes by a continuous levee, thus giving a permanent river-bank, as demanded.

Between the eastern abutment of the bridge and the Coal-Dike the river-bank does not vary materially from where it should ultimately be, and the board think it safe to leave it for the riparian owners to build out and protect.

Below the Coal-Dike there is comparatively little business on either side of the river, until we reach the extensive iron-works in South Saint Louis, (Carondelet,) at which landing there is generally sufficient water. The board believe that ultimately this portion of the river will have to be regulated, and that doing so will require the closing of the channel east of Arsenal Island and the building of several long dikes. The location and cost cannot now be definitely stated. The channel east of Arsenal Island is now receiving large contributions of sediment. The channel should be watched, and, if observation shows that there is danger of the river leaving the channel to the west, prompt measures should be taken to close the eastern channel.

The board are directed to report projects and estimates "which will secure permanence to the channel-way of the river between Alton and the mouth of the Meramec," and also prevent the erosion of the banks.

A literal construction of these orders would require that all of the part included (over forty miles) should be regulated and brought within a fixed channel-way. To do this demands that the slope and volume of the river should be known at the highest and lowest stages, in order that the channel-way may be proportioned properly. These data do not exist, and can only be acquired by careful surveys and measurements. If a perfectly regulated river is to be formed within the limits stated, the undertaking will be immense, and should only be commenced under such impression. It will take years to accomplish it, and the plan will have to develop itself as the work progresses.

A less literal construction of our orders would call for a plan to secure at all stages of the river a channel sufficient for the wants of commerce, without attempting to make the location of the channel permanent.

No surveys other than a simple delineation of the shore-line have been made below the head of Arsenal Island. We are informed by pilots that the only obstruction to navigation within the part of the river specified is the sand-bar between the mouth of the Des Pères River and Jefferson Barracks, where the channel is crooked, and, in extreme low water, but 3½ or 4 feet deep.

There are, however, several other bars between the mouth of the Meramec and the mouth of the Ohio, having no more water on them than this bar has. The removal of it, therefore, is of comparatively little importance until a general system of improvement between Saint Louis and Cairo is undertaken. The necessity for making this latter improvement is very great, and as the data do not exist for devising an adequate plan and estimate, we would suggest that a survey be authorized to ascertain by careful measurements the slopes and volumes of the river at the highest and lowest stages, and the configuration of the bed of the river at all the places where the general navigation requires an increase of depth at low water between Saint Louis and the mouth of the Ohio. An immediate appropriation of $30,000 is recommended for this survey, but it is not improbable that an accurate survey of the whole course of the river between Saint Louis and the mouth of the Ohio will hereafter become necessary, when an additional appropriation will be needed.

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The extension of the dikes already commenced, as proposed by the board, will give a channel-way at the stage of water existing at the time of the survey of December, 1870, of 1,500 feet in width, and at low water of 1,425 feet, approximately, corresponding to the width between the city levee and the opposite East Saint Louis levee, the only portion of the river where both banks are permanent, and where it can with any degree of fairness be said to be regulated.

In a report upon the regimen of the river, made to a convention of civil engineers held in this city to take into consideration the erection of a bridge over the river, it was stated, "when the width of the river is over 1,200 feet, a bar exists either in the middle or at one of the shores."

The authority for this statement is not given, and nothing but a careful survey and long study can test it; but, assuming its correctness, it follows that the lowest water-way should be contracted to the width given. A less contraction might give a sufficient low-water depth entirely across, but, owing to the shifting nature of the sand, in which the slightest excess of current produces an excess of depth, it would be uncertain. The contraction, if required, could easily be made in the upper portion of the harbor by further extending the dikes, but, as this would hardly be necessary while the lower portion was wider, it seems proper that the authorities controlling the levees already built should take the initiative.

The board cannot close this report without remarking that all the dikes or other works herein mentioned cannot fail to make and preserve land which will accrue to the benefit of the riparian owners. The single strip of land that will be made on the Illinois shore by the contraction of the channel above Bloody Island has been estimated at 500 acres, worth about $1,000 per acre. As a general rule, it may be stated that revetments will preserve valuable land, and dikes will form new land, both benefiting riparian owners.

RECAPITULATION OF ESTIMATES.

For erection of dike at harbor of Alton, 6 feet above low water	$40,000 00
Protection of two miles of Sawyer Bend	142,211 62
Extension and raising of dikes in northern harbor of Saint Louis	197,323 90
Survey between Alton and the mouth of the Ohio River	30,000 00

If a high dike is to be built at Alton, the above estimate will be increased by $35,000.

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel of Engineers.
W. F. RAYNOLDS,
Lieutenant-Colonel of Engineers.
G. K. WARREN,
Major Engineers, and Brevet Major-General, U. S. A.
WM. E. MERRILL,
Major of Engineers.
CHAS. J. ALLEN,
Captain of Engineers.

SAINT LOUIS, MISSOURI, *April* 13, 1872.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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We have signed the above report with the expectation that the appropriation of $25,000 asked for in the report from this office of February 17, 1871, for improvement of the mouth of the Missouri, will be made and be applicable for the removal of the obstructions from Mobile Chute, as recommended by the board. The general appropriation for the improvement of the Mississippi, Missouri, and Arkansas Rivers has never been sufficient to justify so large an expenditure in one locality, if it can be avoided.

W. F. RAYNOLDS,
Lieutenant-Colonel of Engineers.
CHAS. J. ALLEN,
Captain of Engineers.

I 11.

OUACHITA RIVER, FROM TRINITY, LOUISIANA, TO CAMDEN, ARKANSAS.

ENGINEER OFFICE UNITED STATES ARMY,
Saint Louis, Missouri, March 15, 1872.

GENERAL: I have the honor to forward herewith the report of Clement Smith, civil engineer, of a survey of the "Ouachita River, from Trinity, Louisiana, to Camden, Arkansas," together with estimates of the cost of improving navigation, so as to give not less than four feet of water at all times.

Agreeing, as I do, with Mr. Smith's opinion, that a lock and dam improvement is demanded by the wants of the country, I have endeavored to have the dimensions of the locks such that, by adapting the boats to their capacity, the wants of commerce would be met with the least expenditure.

The first estimates were for 5 locks, having an average lift of 14 feet, 49 feet wide, and 250 feet between miter-sills. The estimated cost of 5 such locks, built of cut stone, with suitable dams and abutments, is $2,194,916.35. If timber is used instead of stone for the lock-walls, the estimated cost is $1,163,083.75.

Estimates were then made for locks of the same average lift, and 40 feet wide and 200 feet long; the estimated cost of which, built of stone, is $1,995,649.15, a saving of only about 10 per cent.

When the stage of water is such that it will pass over the dams without a fall, boats can of course pass up without using the locks, provided the depth of water on the crest of the dam is sufficient. The aim has been to make the walls so high that the lock will be available until this stage occurs; during this extreme high water boats of larger dimensions than the locks could, and doubtless would, navigate the stream, and the time during which this would be practicable would of course be lengthened by diminishing the height and increasing the number of dams.

To discuss the subject more fully, I have had estimates made of the cost of 10 dams, 7 feet in height, with locks of corresponding lift—40 feet wide and 200 feet long. The estimated cost, if the locks are of stone, is $2,595,114.90, or $400,198.55 more than 5 locks of double the height. The increased time which this would allow large boats to run would hardly justify the additional expense.

The difference between locks 40 by 200 and 49 by 250 being only about 10 per cent., the larger size is preferable. If timber, which it is believed will last twenty-five years, is used for the walls, instead of stone, the estimated cost is decreased by nearly one-half. Such locks

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would meet the requirements of commerce while they lasted, and when decayed could easily be rebuilt, or replaced with stone if then thought desirable.

The estimates given are as low as it is safe to make for work in a region affording so few facilties as that in which this will have to be done.

Respectfully submitted.

W. F. RAYNOLDS,
Lieutenant-Colonel Corps of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

SAINT LOUIS, MISSOURI, *February* 15, 1872.

SIR: I beg leave, very respectfully, to submit this my report of the "survey of the Ouachita River, made last summer," under the instructions contained in your letter of the 3d of July, 1871.

The following papers accompany this report:

1. A profile of the first reach, showing the channel of the river, the surface of low summer water, the high-freshet line, the height of the banks, and the surface of the pools when the improvements shall have been completed with five locks.
2. An estimate of the cost of making the improvement with locks, 49 by 250 feet, constructed of stone.
3. An estimate of cost with five locks, 49 by 250 feet, of timber.
4. An estimate of the cost of making the improvement with five locks, 40 by 200 feet, of stone.
5. An estimate of the cost of making the improvement with ten locks, 40 by 200 feet, of stone.

The survey was commenced at Trinity, Louisiana, on the 8th of August, 1871, but owing to high water little progress was made until the 1st of September, when Catahoula Shoals, a distance of 22¼ miles, were reached. On the 3d of November, though much retarded by sickness, the party reached Camden, Arkansas, the terminus of the survey.

The Ouachita River descends with a very gentle slope from Camden to Trinity, and, joining the Tensas and Little River, at that point, form the Black River, which discharges its waters into the Red River.

The distance between the two places is 297.18 miles, and the fall during low summer water 66.2 feet, or at the rate of .23 foot to the mile. This fall is distributed over a succession of pools and shoals, the first varying in depth from 3 to 30 feet, and in some cases being more than 150 feet—the length of the sounding-line; and the latter having a least depth of 12 to 15 inches in very narrow channels.

These shoals constitute natural dams extending across the river, and are formed generally of gravel.

The width of the surface, during the low summer water, ranges from 100 to 800 feet.

During the high water of winter and spring large boats run to Camden, but during the summer and fall months navigation to that place is suspended.

Practically, navigation above Monroe is limited to six months in the year, and to Monroe seven months; it is continuous during the year to Harrisonburgh, but for small boats only during the fall months.

On the lower part of the river the banks are generally high, ranging from 30 to 45 feet; but in many places they are overflown during high freshets. Above Ouachita City they decrease in height above low water; and vast tracts of land between that place and Camden are yearly inundated by moderate freshets.

It will be observed, by reference to the profile of the river, that while the difference between the levels of the low-water surface at Camden and Trinity is 66.20 feet, the difference between the high-freshet levels at those two points is only 43 feet.

This piling up of the water on the lower parts of the river is in part attributable to the decreased slope, and partly to the great volume of water poured into the Ouachita by the Bayou Bartholomew, which it receives from the Mississippi, during high water, through the breach in the levee near Lake Providence.

If this breach could be repaired, a large body of land now uncultivated could be reclaimed.

Timber of all kinds abounds along the banks of the river and its tributaries, and large quantities are yearly rafted to market.

At one or two points on the upper part of the river veins of brown coal outcrop near the low-water surface on the banks. They are about 3 feet thick.

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The motive for the improvement of this river is, chiefly, to facilitate the shipment of cotton and the return of plantation-supplies, nearly all of the latter of which are brought from the Northwestern States.

The country that will be tributary to this river is, perhaps, unrivaled in the United States in its adaptability to the production of cotton. The climate and the soil are both eminently adapted to it, and in the face of difficulties interposed by remoteness from market and the want of proper means of transportation, the production goes on increasing beyond the increase of population.

In the State of Arkansas alone there are fifteen million acres of cotton-land, of which ten million acres are bottom-land. Such soil does not fail in any year, under tolerable cultivation, to produce more cotton than can be gathered by so sparse a population.

That State, once fully settled up and entirely under cultivation, is capable of a yearly production of cotton considerably greater than the present supply from the whole world.

At present, the planter in South Arkansas pays an average of at least 20 per cent. on the value of his cotton to get it to market, when it bears a high price, and more than that when it is low, and has to submit to a like tax in getting back his plantation-supplies.

The improvement of this river, by which regular transportation at low rates will be secured throughout the year, will lead to the construction of railroads and turnpikes, connecting it with the cotton region in every direction. The Red River raft will be effectually flanked by a railroad now projected from Camden, about 60 miles in length, which will be constructed on or before the completion of the river-improvements, and the whole of the fine cotton-producing country for many miles south of that river will find an outlet at cheap rates by a direct route to market.

As before stated, navigation to Camden is limited to six months in the year. During two months of these six it is so uncertain that, practically, it is limited to four months, during which the prudent merchant and farmer, when they have the means of doing so, lay in their supplies for the succeeding season of eight months.

In addition to the large capital required to transact business of this kind, there is great risk from fire, and certain loss from decay and the attacks of insects, &c.

But in many cases the planter, from lack of means to purchase so much in advance of his wants, is compelled to haul his cotton to distant points during the suspension of navigation on the Ouachita, at an expense of $10, $15, and, in some cases, $20 per bale, and to bring back his plantation-supplies at the same extravagant rates. Such a tax on productions would seem sufficient cause for the depopulation of the country.

The following statement of the quantity of cotton annually shipped from the Ouachita River was furnished to me by gentlemen of experience, and I think it may be relied on as approximating pretty nearly to the truth:

	Bales.		Bales.
Camden	30,000 to 40,000	Alabama Landing	2,000
Newport	1,500	Bayou Bartholomew	10,000
Little Bay	1,500	Russel Landing	600
Miller's Bluff	2,000	Morehouse Point	600
Avery's Landing	400	Ouachita City	1,500
Boark's Landing	600	Trenton	20,000
El Dorado Landing	2,000	Monroe	9,000
Champagnolle	2,200	Columbia	8,000
Wilmington	1,500	Bœuf River	5,000
Moro Landing	2,500	Harrisonburgh	6,000
Pigeon Hill	1,000	Trinity	6,000
Caryville	12,000	Plantations along the river	15,000
Marie Saline	5,000		
Roland's Raft	1,200	Total	157,100

About 125,000 bales go direct to New Orleans.

Camden, as will be seen by the above, is the principal place of shipment, the quantity of cotton sent from that point being rather more than one-fourth of the whole quantity sent to market by the river. It is the center of trade for Pike Clark, Hot Springs, Dallas, Hempstead, Sevier, Calhoun, and Bradley Counties.

Should the improvement of the river be completed, the following additional counties will find their best and cheapest outlet through the same place: Ashley, La Fayette, Polk, Montgomery, and also the whole country of the Choctaw and Chickasaw Indians lying north of Red River, and the two tiers of counties in Texas south of Red River, all of which will be connected with the river by the proposed railroads to Camden.

Camden, now one of the most industrious and prosperous little towns in the country, will become the center of a vast commerce and one of the great cities of the Southwest if the proposed improvements should be made.

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I gauged the river near Monroe, at a time when it was reported to be about 10 to 12 inches above its lowest stage, and found the discharge to be a little more than 800 cubic feet per second. It was my intention to gauge it again at Camden, but the wind, during my stay at that place, was too high to allow me to do so. While it was evident that there was abundant water for the supply of locks for any possible amount of business on the river, it was quite as evident that there was not enough for any other mode of improvement than that by locks and dams, which would give continuous navigation to Camden.

Allowing 200 cubic feet per second as the increased discharge due to the 12 inches of elevation of the water above its lowest summer level, there would remain 600 cubic feet as the discharge of the river at Monroe during the low stages.

As the affluents between Camden and Monroe, during the dry summer months, contribute but a small portion of the water that flows between those places, it will be safe to assume two-thirds of the quantity that flows past Monroe as the discharge of the river at Camden. This would leave 400 feet for the quantity passing Camden during low summer water per second; more than enough for any possible demand for the business that may be expected on the river at that point.

At this stage of the water a boat 250 by 49, by 4 feet displacement, could pass through the locks, which would be about 1,300 tons. The cargo of such a boat would be about 650 tons. If barges should be used, as most probably would be the case, as most suitable to the business, the cargo, with such a displacement, would be 975 tons. Allowing 5 bales of cotton to the ton of 2,250 pounds, the cargo would be in the latter case 4,875 bales.

The quantity of water used in passing such a boat through the lock down the river would be about 125,000 cubic feet, and the time required would ordinarily be about 20 minutes.

The flow of the river at Camden, being about 400 cubic feet in its low summer stage, would in that time be 480,000 cubic feet, or more than three times as much water as would be required to pass the boat.

So that, making the most ample allowance for leakage, &c., there will be more than a supply of water for any amount of business that may be expected.

MODE OF IMPROVEMENT.

After a thorough examination of the river, I have come to the conclusion that, in consequence of the small quantity of water discharged during its low stages, the only practicable improvement which will secure the ends sought is that by locks and dams.

Five of these, with an average lift of 14 feet, will secure 4 feet of water during the lowest stages of the river in summer, and 7 to 8 feet during ordinary winter water.

With some slight work, navigation can be obtained at all seasons to Catahoula Shoals, and I propose to locate the first dam at that point.

A good foundation of gravel can be had at that point, and the banks are high and sufficiently stable. The dam will be about 600 feet long, and will give back-water to the second lock and dam, a distance of 82.4 miles.

The second lock and dam will be located at Taylor's Shoals, 82.4 miles distant from the first, where also a good gravel foundation can be had. The length of this dam will be about 660 feet, and the length of the pool created by it will be 41.26 miles.

The third lock and dam will be located at Rock Roe. At this point the lock will have a soft sandstone foundation. The dam will have a foundation partly of gravel and partly of sandstone. The length of the dam will be about 900 feet, and the pool created 77.17 miles.

The fourth will be at Jackson Island, where a gravel foundation can be had. The length of the dam will be about 1,000 feet, and the pool created 52.70 miles.

The fifth will be located at Buffalo Shoals, on a gravel foundation. The length of the dam will be about 400 feet, and the pool created will be 21.5 miles. This dam will give back-water some distance above Camden.

The locks will all be precisely of the same dimensions, viz, 30 feet high, and capable of passing boats 250 feet long and 49 feet wide. The average lift will be 14 feet.

The survey was somewhat hurriedly made, as the long detention of the party on the lower part of the river by high water left but little time during which it could be made with advantage.

The location of these dams may possibly, on a further examination, be advantageously changed.

COST OF THE IMPROVEMENT.

I have estimated the cost of completing the five locks and dams, if the locks should be constructed of stone, at $2,194,916.35.

As there is no stone of suitable quality for solid masonry on the river, it will have to be brought from a distance. If they should be of solid masonry, I have estimated for stone of the kind of which the locks at Louisville are constructed by the Govern-

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ment, a fine sandstone, brought from Vernon, Indiana. If they should be built of timber, the stone filling can be found at convenient points on the river. The cost will then be $1,163,083.75.

The dams I propose shall all be built of timber, as most suitable for the foundation to be had.

Timber locks will answer all the purposes of stone locks so long as they last, which will be about twenty-five years for that part above water.

The foundations being built precisely of the same material, and in the same way as those for the stone, and being always covered with water, will last for an indefinite period. The upper part of the lock-wall can be readily repaired at a moderate expense.

The advantages to be derived by the Government by the completion of this improvement consist of the enhanced value of the public lands in Southwestern Arkansas, now, in consequence of their inaccessibility, unsalable, but which will have a cheap outlet to market by the river, when it shall be made navigable at all seasons of the year, and the increased revenues which may be expected from the development of the resources of a wide area of country, almost unrivaled in its adaptability to the production of cotton.

The value of the annual crop now sent to market is at least ten million dollars, and the return of plantation-supplies received from the Northwestern States, in the shape of manufactured goods, mules, flour, pork, bacon, and even corn, to some extent, probably amounts in value to two-thirds of this sum.

The encouragement which will be offered to increased cultivation by the cheap transportation which will be afforded by the river, when improved as proposed, will doubtless in a few years increase the value of the exports and imports to double the present amount.

Very respectfully, your obedient servant,

CLEMENT SMITH,
Civil Engineer.

General W. F. RAYNOLDS, U. S. A.
Saint Louis, Missouri.

Estimate of cost of five locks, 250 by 49 feet, and dams for the Ouachita River, and contingent expenses, in making the same navigable to Camden, Arkansas, from Trinity, Louisiana.

LOCK OF MASONRY.

Coffer-dam, and preparing foundation for lock		$15,500 00
10,500 feet piling, at 30 cents		3,150 00
166,140 feet planks for foundation and flooring of lock-chamber, $40		6,645 60
14,014 feet of timber for foundation, at 35 cents		4,904 90
Miter-sills		280 00
73,584 feet sheet-piling, at $40		2,943 36
4,000 pounds spikes, at 12 cents		480 00
9,031 cubic yards of masonry, at $25		225,875 00
Lock-gates with irons, complete		4,500 00
708 yards concrete in foundations, at $6		4,248 00
2,000 yards puddling, at 80 cents		1,600 00
2,550 yards graveling, at 50 cents		1,275 00
300 yards riprapping, at $2		600 00
		272,001 86

PIERS.

37,150 feet of timber, at 35 cents	$13,002 50	
7,218 yards stone packing, at $1.50	10,827 00	
2,400 tree-nails, at 5 cents	120 00	
1,000 feet piling, at 30 cents	300 00	
36,000 feet sheet-piling, at $40	1,440 00	
		25,689 50
Cost of lock and piers		297,691 36

DAM.

Coffer-dam, and preparing foundation for dam and abutment	$15,250 00
76,020 cubic feet of timber, at 35 cents per foot	26,817 00
135,000 feet sheet-piling, at $40 per 1,000 feet	5,400 00
57,600 feet plank on top, at $30 per 1,000 feet	1,728 00

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9,603 yards stone packing, at $1.50 per yard		$14,404 50
600 screw-bolts and taps, (4,050 pounds,) at 15 cents		607 50
17,600 pounds spikes, 20 inches by ½, at 12 cents		2,112 00
2,462 pounds spikes, 14 inches by ½, at 12 cents		295 44
6,300 pounds spikes, 6 and 8 inches by ½, at 12 cents		756 00
9,000 yards graveling, at 40 cents		3,600 00
2,000 feet piling, at 30 cents		600 00
		71,570 44

ABUTMENT.

1,250 feet piling, at 30 cents	$375 00	
22,800 feet sheet-piling, at $40	912 00	
6,300 feet foundation-plank, at $30	189 00	
500 pounds spikes, at 12 cents	60 00	
10,170 feet timber, at 35 cents	3,559 50	
600 spikes, 20 inch by ½, (1,320 pounds,) at 12 cents	158 40	
1,008 yards masonry, at $20	20,160 00	
500 yards puddling, at 50 cents	250 00	
500 yards embankment, at 30 cents	150 00	
500 yards riprapping, at $2	1,000 00	
2,000 yards stone packing, at $1.50	3,000 00	
		29,813 90
Cost of dam and abutment		101,384 34

SUMMARY.

Lock and piers	$297,691 36
Dam and abutment	101,384 34
Total cost of one lock and dam	399,075 70
Add 10 per cent. to cover cost of dredging at foot of locks, and contingencies	39,907 57
Cost of one lock and dam, and contingencies	438,983 27
Cost of five locks and dams, and contingencies	$2,194,916 35

These locks will all be of precisely the same dimensions, and the dams will be of the same height and width at base. They will only vary in the length. The average length of 600 feet is estimated for, which will give sufficiently correct results.

Estimated cost of timber lock, 250 by 49 feet.

Coffer-dam and preparing foundation for lock	$15,500 00
10,500 feet piling, at 30 cents per foot	3,150 00
166,140 feet plank for flooring, at $40 per 1,000 feet	6,645 60
14,014 feet timber for foundation, at 35 cents	4,904 90
73,584 feet sheet-piling, at $40	2,943 36
Miter-sills, (timber)	280 00
9,000 pounds spikes, 6 and 8 inches, at 12 cents	1,080 00
45,000 feet timber in walls, at 35 cents	15,750 00
10,198 yards stone filling, at $1.50	15,297 00
170,400 feet sheeting, sides of lock, at $40 per 1,000 feet	6,816 00
10,184 pounds spikes, 20 inches by ½, at 12 cents	1,222 08
Gates, complete, with irons	4,500 00
472 yards concrete, at $6	2,832 00
2,000 yards puddling, at 80 cents	1,600 00
2,550 yards graveling, at 50 cents	1,275 00
300 yards riprap, at $2	600 00
Cost of lock	84,395 94
Piers, as in stone lock	25,689 50
Dam and abutment, as in stone lock	101,384 34
Total	211,469 78
Add 10 per cent. for dredging at foot of lock, and contingencies	21,146 97
Cost of one lock and dam, and contingencies	232,616 75
Total cost of five locks and dams	$1,163,083 75

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Estimate of cost of 5 locks and dams for the Ouachita River, the locks to be 200 feet by 40 in the chamber, and 14 feet lift.

LOCK OF MASONRY.

Coffer-dam, and preparing foundation	$14,500 00
10,500 feet piling at 30 cents per foot	3,150 00
125,400 feet planks for foundation, at $40 per M	5,016 00
11,466 feet timber for foundation, at 35 cents per foot	4,013 10
Miter-sills	280 00
66,384 feet sheet-piling, at $40 per M	2,655 36
3,500 pounds spikes, at 12 cents	420 00
7,806 yards masonry, at $25	195,150 00
Lock-gates, with irons, complete	4,500 00
542 yards concrete, at $6	3,252 00
1,700 yards puddling, at 80 cents	1,360 00
1,750 yards graveling, at 50 cents	875 00
300 yards riprapping, at $2	600 00
Cost of lock	235,771 46
Piers as in stone locks, 49 by 250	25,689 50
Dams and abutment	101,384 34
Total	362,845 30
Add 10 per cent. for contingencies	36,284 53
Cost of one lock and dam	399,129 83
Cost of five locks and dams	$1,995 649 15

Estimate of cost of 10 locks and dams for the Ouachita River, 200 by 40 feet in chamber, and 7 feet lift.

LOCK.

Coffer-dam, and preparing foundation	$14,500 00
10,500 feet piling, at 30 cents per foot	3,150 00
115,200 feet planking for bottom, at $40	4,608 00
9,850 feet timber in foundation, at 35 cents	2,447 50
66,384 feet sheet-piling, at $40	2,655 36
Miter-sills	280 00
3,500 pounds spikes, at 12 cents	420 00
4,675 yards masonry, at $25	116,775 00
Lock-gates, with irons, complete	3,750 00
474 yards concrete, at $6	2,844 00
1,400 yards puddling, at 80 cents	1,120 00
1,306 yards gravel, at 50 cents	653 00
300 yards riprap, at $2	600 00
	154,802 86

PIERS.

22,800 feet of timber, at 35 cents	$10,080 00	
4,080 yards stone packing, at $1.50	6,120 00	
1,800 tree-nails, at 5 cents	90 00	
1,000 feet piling, at 30 cents	300 00	
36,000 feet sheet-piling, at $40	1,440 00	
		18,030 00
Cost of lock and piers		172,832 86

DAM.

Coffer-dam, and preparing foundation for same, and for abutment	$14,000 00
36,980 feet of timber, at 35 cents	12,908 00
57,600 feet plank on top, at $30	1,728 00
82,800 feet sheet-piling, at $40	3,312 00

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4,963 yards stone packing, at $1.50	$7,444 50
4,050 pounds screw-bolts, at 15 cents	607 50
9,000 pounds spikes, 20 by ½, at 12 cents	1,080 00
6,300 pounds spikes, 6 and 8 inches by ½, at 12 cents	756 00
4,360 yards gravel, at 40 cents	1,744 00
2,000 feet piling, at 30 cents	600 00
	44,180 00

ABUTMENT.

1,250 feet piling, at 30 cents	$375 00	
22,800 feet sheet-piling, at $40	912 00	
6,300 feet foundation-plank, at $30	189 00	
500 pounds spikes, at 12 cents	60 00	
8,100 feet timber, at 35 cents	2,835 00	
989 pounds spikes, 20 by ½, at 12 cents	118 68	
537 yards masonry, at $21	11,277 00	
500 yards puddling, at 50 cents	250 00	
500 yards embankment, at 30 cents	150 00	
500 yards riprap, at $2	1,000 00	
1,160 yards stone packing, at $1.50	1,740 00	
		18,906 68
		63,086 68

SUMMARY.

Estimate of cost of 1 lock and piers	$172,832 86
Estimate of cost of 1 dam and abutment	63,086 68
Cost of 1 lock and dam	235,919 54
Add 10 per cent. for contingencies	23,591 95
Total	259,511 49
Cost of 10 locks and dams, and contingencies	$2,595,114 90

I 12.

WHITE RIVER, FROM BUFFALO SHOALS, ARKANSAS, TO THE MOUTH OF JAMES FORK, MISSOURI.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Missouri, March 20, 1872.

GENERAL: I have the honor to forward herewith a report of Alonzo Livermore, esq., civil engineer, of an examination of White River from Buffalo Shoals, in Arkansas, to the mouth of James Fork, Missouri, made under my direction.

The examination was not made with reference to improving the stream by locks and dams, which will be necessary if it is attempted to secure navigation throughout the entire year. Such an improvement would require some twenty locks, of 10 feet lift, and could not be made without the expenditure of several millions of dollars, which would not be justified by the present wants of the country.

Buffalo Shoals is the worst point on the river, the fall being 9.5 feet in the distance of one and one-fourth miles. I was unwilling to forward the estimates for improving this locality without availing myself of all the experience I could command to judge of its feasibility, and estimate its probable cost. Accordingly, I had a special examination of it made by Clement Smith, esq., civil engineer, who, as well as Mr. Livermore, has had large experience in river improvement. Both these engineers

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gave it as their opinion that by constructing dams, so as to confine the water-way to what will be just sufficient to carry the water at the stage at which it is proposed to make the stream navigable, a succession of pools will be formed, with chutes between them, up which it is estimated a boat would be able to pass, the fall in the chutes being in no case greater than 12 inches. The method is not new, but I am not aware that it has ever been tried to any extent in this country. It is one which commends itself to my judgment as well worthy of a trial. The estimates of Messrs. Livermore and Smith are so nearly the same that I regard it as unnecessary to forward them both.

The improvement, if completed, would greatly facilitate commerce.

Very respectfully, your obedient servant,

W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

OSAGE RIVER, MISSOURI, *November* 9, 1871.

SIR: I have the honor herewith to report my examinations of obstructions upon White River, from James Fork, in Missouri, to the foot of Buffalo Shoals, in Arkansas, a distance, by my estimate, of 194 miles.

I left Saint Louis, Missouri, on the 10th of June last, and reached Maberry's Ferry, on the White River, June 13, at which place I obtained a small flat-boat with which to proceed down stream.

The examinations were commenced on the 21st at the mouth of James Fork. The estimated distance from this fork to Forsyth, Missouri, is fifty-two miles. This point I reached Saturday evening, June 24. This may be considered the termination of the first section. The rest of the distance to Buffalo Shoals, having been examined last year, will form a separate section.

Before entering upon the details of this report it may be well to make some general remarks.

The improvement of White River, as herewith estimated, does not embrace a true low-water channel, such as is being made upon the Osage River, but is intended to include the removal of all obstructions to navigation when there is a rise of 5 feet above low water upon the head of the principal shoals. The fall of some of these shoals is too great for an improvement at a moderate low-water stage, unless at a very great expense, which the resources of the country do not now justify. At present, a navigation which will permit steamers and other craft to ascend and descend, when there is a rise of 5 feet or over upon the shoals, is all I can now recommend as admissible in the expenditure of public funds.

Thus far I have no hesitation in saying that I believe such an improvement as herein is recommended is worthy of an appropriation to the extent of my estimate. The country, to be sure, is far from being developed, either in its agricultural or mineral resources; much of this is owing to the want of facilities for getting to market with these products when obtained, and getting supplies of salt, groceries, and other necessary articles, at a reasonably cheap rate.

The bottom-lands upon this river are not extensive; but what there are will compare favorably with any other bottom-lands along the rivers of the States.

The hills are high and the land considerably broken; still there is some very good land in the valleys and low elevations bordering the small streams, and most of the hills afford a fine range for stock.

The hills along this stream have, undoubtedly, much mineral wealth, which is yet far from being developed. Iron and lead, I judge, will be found quite abundant; other minerals, such as copper and zinc, are said to exist in many places. Upon the whole, I am of the opinion that this country, in due time, will teem with population and wealth, more from its mineral resources than from its agricultural products, which, at best, will only supply the miners and their families if such become numerous.

SECTION NO. 1.—*From James Fork to Forsyth, a distance estimated at 52 miles.*

We found 59 shoals on this section. My estimate of the fall at these shoals, together with the estimated fall of the pools, amounted to 80.25 feet, which is an average of

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1.55 feet per mile. The water in the river, at the time we examined this section, was believed to be from 12 to 15 inches above low water.

The pools I found to be from 2 to 10 feet deep; generally not over 6 feet; the deepest channel upon the shoals, about 15 to 18 inches. As we descended the river we found the water lessening in depth upon the shoals, so that at Forsyth it could not be over 12 inches above low water. The width of the river upon this section will average about 350 feet.

The obstructions to navigation do not materially differ from those found in a similar number of miles below Forsyth.

Names, &c., of the worst shoals in this section, with the estimated cost of their improvement.

China Bowman Shoals, No. 25.—This shoal should have a dam across the right-hand channel, estimated at a cost of $2,000.

Long Creek Shoal, No. 28.—The river divides into several channels. The right-hand ones must be closed by dams. The cost of the work here is estimated at $4,000.

First shoal above Bull Shoal, No. 41.—This shoal should be improved by a dam across left-hand channel, the cost of which I estimate at about $2,000.

Bull Shoal, No. 42.—This channel is very crooked, and should be straightened, and a wing-dam built to concentrate the water. The cost estimated at $4,000.

Jenning's Shoals, No. 50.—A wide gravel-bar on the left. An old dam here extends too far toward the right shore, a portion of which must be removed; the other end extended to the left shore. This shoal has an estimated fall of 2.5 feet. The improvement of this shoal will cost about $5,000.

Shoal No. 52.—A brush and gravel dam required across one channel. The water here divides into nearly two equal parts. Required, a brush dam, estimated to cost $500.

Shoal No. 56.—Water spreads over a wide surface and should be concentrated by a brush and gravel dam, which is estimated to cost $500.

The seven miles upon which these shoals are situated are therefore estimated to cost $18,000. The balance of the distance the cost will be light, and may be estimated at $50 per mile, $2,250.

Total cost of fifty-two miles	$20,250 00
Add 50 per cent. for contingencies	10,125 00
Grand total	30,375 00

SECTION No. 2.—*From Forsyth, Missouri, to the foot of Buffalo Shoals, in the State of Arkansas, which we estimated by our run this year at one hundred and forty-two miles.*

This is considerably more than was estimated last year. A part of the examination last year of this section was made when the river had risen some 4 or 5 feet, which I judge, to some extent, caused an underestimate.

I, however, am of the opinion, while last year's run was underestimated, the estimate for this year may be too great. Actual measurements only can determine the true distance.

For the first one hundred miles, as estimated last year, I can hardly improve the figures. With 50 per cent. added to my estimate, instead of 20 which I then made for contingencies, I shall cover the difficulties suggested by your report of last year upon this work. In reviewing the river, I am satisfied that your remarks upon the difficulties to be encountered are strictly just.

The estimated fall of the shoals of this section is somewhat greater than I estimated last year. The pools I now estimate at 4 inches instead of 6 inches per mile, as per last year's report. The whole fall, therefore, is slightly less than my previous estimate.

The shoals number 130 from Forsyth to the foot of Buffalo, with an aggregate fall estimated at 159.10 feet, to which add 4 inches per mile for the pools, making in all 206.43 feet, or 1.45 feet per mile. The bad shoals upon this section, which require considerable engineering skill to improve, number 12. These shoals have mostly local names, and are situated in the following order upon the miles, as numbered this year, namely:

	Miles.		Miles.
Double Shoal	26	Bull Shoal	113
Elbow Shoal	54	Wild Cat Shoal	125
Tumbling Shoal	64	Summer Shoal	129
Bull Bottom Shoal	87	Red Bud Shoal	132
Pott Shoal	94	Crooked Creek, (two shoals)	136
McGar Shoal	99	Buffalo Shoals	141, 142

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The cost of improving these shoals is estimated as follows, viz:

Double Shoal	$500	Wild Cat Shoal	$500
Elbow Shoal	5,880	Summer Shoal	500
Tumbling Shoal	1,500	Red Bud Shoal	2,000
Bull Bottom Shoal	700	Crooked Creek Shoal	2,500
Pott Shoal	1,500	Buffalo Shoal	18,000
McGar Shoal	6,250		
Bull Shoal	2,200	Exclusive of contingencies	42,030

Exclusive of contingencies, (brought forward)	$42,030
To this add, for 130 miles requiring little work or engineering skill, at $40 per mile	5,200
	47,230
For contingencies add 50 per cent	23,615
Grand total	70,845
Add grand total section 1	30,375
Grand total for two sections and 194 miles of distance	101,220

The estimate for section No. 2 varies mainly from last year's estimate by a considerable increase of funds required for Buffalo Shoals. These shoals were examined this year carefully under favorable circumstances. The river was low and I took a level of the whole fall, which I found to be 9.5 on a distance of only one and one-fourth miles. Last year the estimate of these shoals was ten feet fall, and the length two miles. The fall this year was found to be 7.6 feet per mile, while last year the fall was 5 feet per mile. It is evident, therefore, that it would require greater skill and a greater expense to overcome the force and velocity of the water, in order to permit boats to ascend in such a moderate rise as 4 or 5 feet.

The bottom of these shoals is solid rock the whole length: there are large quantities of loose rock upon the shoals, which can be placed in dams at a low cost. These dams should be frequent, not less than 16 in number, and will contain about 500 cubic yards of stone each. The cost per yard may be set down at $1.12½, making this item $9,000. The amount required for excavating the channel I place at the same figures as last year, viz, 3,000 cubic yards at $3 per yard, thus making the total expense of improving the shoals $18,000. Owing to the great fall on these shoals, and the limited distance from the head to the foot, I am satisfied that these shoals are now largely the greatest obstacle to an ascending navigation at moderate floods on this river. The work of improving the same should be done under the direction of a practical and scientific engineer.

I feel satisfied, therefore, in making a large increase in my estimate for this work over the amount thought sufficient, under the circumstances, by me, as you find by last year's report.

I respectfully refer you to my last year's report for the details of my plan for improving Elbow and McGar Shoals, which, next to Buffalo, are the most important shoals to be improved. The width of the river from Forsyth to Buffalo Shoals is fully 400 feet upon an average.

The height of the bottom-lands will average about 23 feet above low water, and the highest flood known 28 feet, the place having been pointed out to me by the citizens of Forsyth. In my report of last year I stated I had measured the water of White River, and found it to discharge 264 cubic feet per second. This measurement was made when the water was at its lowest stage. The oldest inhabitants told me they never knew this stream to be lower than it was last season. One-half of this quantity would fill a lock of 10 feet lift, 60 feet wide, and 250 feet between the gates, every 19 minutes. This would allow one-half of the water as wastage through the dam and lock gates.

Very respectfully, your obedient servant,

ALONZO LIVERMORE,
Civil Engineer.

General W. F. RAYNOLDS,
Lieutenant-Colonel U. S. Corps of Engineers.

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I 13.

BLACK RIVER, MISSOURI, TO POPLAR BLUFF.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Missouri, March 26, 1872.

GENERAL: I have the honor to submit herewith the report of A. H. Blaisdell, civil engineer, of an examination made, under my direction, of Black River, Missouri, to Poplar Bluff, as required by the provision of the act of Congress making appropriation for the repairs, preservation, and completion of certain public works on rivers and harbors, and for other purposes, approved March 3, 1871.

This stream is more favorable for navigation than is common to streams of its size, the least depth on the shoals being 2 feet, which is sufficient for a class of boats which would carry fair loads, and be of great benefit to the country if no other commercial channels were open. The obstructions to navigation consist, as in all smaller streams in this region, almost exclusively of snags and leaning timber.

But three shoals exist where it is proposed to do any work, and these are of small extent, the proposed improvement consisting only in widening the channel.

The channel is so narrow and crooked that large boats could not navigate the stream, even if the depth of water was sufficient. Hence, if the snags and leaning timber are removed, a few sloughs closed, to confine the water at its lowest stage to a single channel, and the channel at the three shoals widened, it would be all the improvement which could in any way be considered justifiable.

The removal of the snags and leaning timber will be somewhat expensive, as they must be removed to points where they will not be taken back into the channel during high water. The use of a boat with propelling power is essential for the purpose, and Mr. Blaisdell's estimate of $90,561 for the work, after a boat shall have been provided, is as low as it is safe to make. A small steamer, such as would be required, will cost at least $20,000, making the total estimate for the proposed improvement $110,561.

In considering the wants of the country in connection with this improvement it should not be forgotten that the Cairo and Fulton Railroad, now under construction, touches Black River at Poplar Bluff, crosses it twelve miles below the State line of Arkansas, and White River three miles below the junction, throughout this entire distance running parallel to the river at a distance from it of from six to fourteen miles.

Very respectfully, your obedient servant,

W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Missouri, March 11, 1872.

GENERAL: I have the honor to submit the following report on the recent examination of Black River from Poplar Bluff, Missouri, to Pocahontas, Arkansas, to which duty I was assigned by orders from this office dated November 13, 1871.

Black River rises in the western part of Iron and the northern part of Reynolds County, in Southeastern Missouri, and flows in a general direction southeast through that State, parallel to the Saint Francis River, and at an average distance from it of

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fourteen miles, traversing the counties of Reynolds, Wayne, and Butler, when it strikes the Arkansas line and diverges toward the southwest, touching the edge of Greene, flowing through Randolph and Lawrence, forming the boundary-line between Independence and Jackson Counties, and empties into the White River one-half mile above the city of Jacksonport.

From its source to Poplar Bluff the river flows through the mountainous country of the Ozark Ranges and their spurs, and then leaves the mountains and seeks the lowlands, through which it continues to flow, without any elevation on its banks higher than 25 feet above low water, until it again strikes the hills at Pocahontas.

Between the limits of this examination the principal tributaries are Cane Creek, Current River, and Fourche Dumas, in Arkansas, and a large number of sloughs in Missouri, which drain the country between this stream and the Saint Francis River, one of which connects the two rivers, and in which the current has either an easterly or westerly direction, according to the water-level in the two streams.

The total drainage area of the Black River and its tributaries may be estimated at 8,000 square miles.

The river frequently divides itself into branches; hence we have Dan's River, Little River, and Catharine Slough. Again, sloughs fork into the swamps, which in the dry season much diminish the quantity of water in the river.

Throughout its whole length the river pursues a very winding course. The bottom-lands are low, varying from 18 feet at Poplar Bluff to 2 feet in places at Dan's River, and from 18 to 20 feet at Pocahontas above low water, while the difference of level between extremes of water varies from 18.5 feet at Poplar Bluff to 5 feet at Dan's River and 26.25 feet at Pocahontas.

The river-bed is generally sand, or in its lower part sand and clay, sometimes mingled with muscle-shells and fine gravel.

There are 54 shoals in the river, having a sandy bottom, generally occurring in bends, and which have much increased in size from the quantity of snags and drift-wood accumulated in such places.

These shoals cover an aggregate length of 3.7 miles, but the average depth of water upon them in the low-water season is never less than 2 feet. In addition to these there are three shoals called Cox's, Fish-Trap, and Rocky, which have a rock bottom of a ferruginous sandstone conglomerate, friable in its nature, and extending over the whole width of the river. The depth on these shoals averages 2 feet in the channel, and their aggregate length is .25 mile. The beginning and termination of these shoals are very abrupt, and the formation is a peculiar one. Borings for wells in the immediate vicinity of the shoals failed to encounter similar rock, but at a depth of 40 or 50 feet a bed of limestone was struck.

The general depth of the river in its upper part is not great, and the channel is often very narrow. The general width between banks is 130 feet, but in some of the "cut-offs" the river has made, and in the portion of the main river adjoining Davis and Little Rivers, the width varies 50 to 90 feet; below the mouth of the Current River the river is 225 feet wide.

The current of Black River at Poplar Bluff, at low water, when the examination was conducted, had a velocity of six-sevenths mile per hour; in no place did the current exceed a velocity of 1½ miles per hour, except on the three rocky shoals mentioned above.

I estimate the distance between Poplar Bluff and Pocahontas at 161 miles, and place the fall in the water-surface between those limits at 36 feet.

As an appendix to this report a list of the shoals is given, their length, width, and depth of low-water channel.

CHARACTER OF THE ADJACENT COUNTRY.

Leaving the last spur of the Ozark Mountains, on which Poplar Bluff is situated, we enter at once a swampy country, which is annually overflowed to a depth varying from 6 inches to 6 feet.

On the right bank of the river there is a second bottom, which is very fertile, and is extensively cultivated. On the left bank there are few elevations above overflow, until Gillis's Bluff is reached, forty miles below Poplar Bluff, which is about 24 feet above low water, and of considerable extent; the banks from this point down average higher than above, and exhibit more clay in their composition.

The upper half of Butler County, Missouri, is not so well adapted for the cultivation of cotton as the lower half. The lands bordering the river in Arkansas are eminently adapted for the production of cotton, and this is the chief farming product. The country adjacent to the river abounds in every kind of timber except pine and cedar, but both of these varieties are found in the hills north and west of Poplar Bluff. The lumber interest is a large one; poplar and cypress are annually rafted in considerable quantities. Poplar is not found below the Arkansas line. The white-oak timber, especially, is worthy of mention; parties are at present engaged in getting out large quantities of it at the head of Dan's River for ship-building purposes.

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In Arkansas the tract of land lying between the Black and Current Rivers is called the "Cherokee Bay country," and is probably the most fertile and thickly-settled farming country on the river. On the first terrace of this portion of the valley an excellent quality of black walnut is found, and large quantities of it are under preparation for shipment to New York and Boston.

Between Poplar Bluff and the mouth of the river there are ten steam saw-mills.

A very good quality of iron ore (brown hematite) is found in the north and west parts of Butler county, but no mines have yet been opened.

TOWNS, RAILROADS, ETC.

Poplar Bluff, the county-seat of Butler county, Missouri, is situated on the right bank of the river, on an elevation 60 feet above low water. In 1870 it had a population of 400, but since that time it has increased to about 800, while the valuation of its real estate has been enhanced over 200 per cent. The extension of the Pilot Knob branch of the Iron Mountain Railroad intersects the Cairo and Fulton Railroad one and three-quarters miles above the town, and the latter road runs directly through it. It is expected that cars will be running to Poplar Bluff in July next.

The grading of the Cairo and Fulton Railroad is being rapidly pushed in the State of Arkansas toward and from Little Rock; the road crosses Black River about ten miles below the State line on the eastern edge of township 20, range 4 east of the fifth principal meridian, and then, confining itself to the left bank, runs parallel to the river at a distance from it of from six to fourteen miles, crosses the White River at Elizabeth, three miles below Jacksonport, thence runs by way of Little Rock to Fulton, Arkansas, on the Red River, and connects with the South Pacific road at some point in Texas.

The Cape Girardeau and State Line Railroad is at present under construction, and is graded within nineteen miles of Poplar Bluff, where it will intersect the trunk line. The Memphis and Saint Louis Railroad is proposed, and will intersect the same line.

Everything seems to indicate that Poplar Bluff will be the principal town of Southeastern Missouri. As far as railroad facilities are concerned, there are but few inland towns which will surpass it. It at present contains eight stores, which do a business of $120,000 in general merchandise. Goods heretofore were hauled in wagons to the town from Pilot Knob, on the Iron Mountain Railroad, or from Cape Girardeau, on the Mississippi River.

Pocahontas, the county-seat of Randolph County, Arkansas, is situated on a bluff, 120 feet above low-water mark, on the right bank of the river. The town is the shipping point for a large section of country, extending up Black and Current Rivers, and a regular line of boats is kept up to the town for the entire year. It contains a population of about 800, and sells $350,000 worth of merchandise yearly; 2,500 bales of cotton and about 5,000 dressed hogs were two items in her shipments last year; 1,000 bales of this cotton were raised in the country adjacent to Black and Current Rivers.

Ten thousand bales of cotton is a low estimate for the entire quantity shipped in the Black River Valley.

PREVIOUS IMPROVEMENTS.

Butler County, Missouri, some time before the late rebellion, had donated to her by the State a large quantity of swamp-lands for internal improvement purposes. In 1859, 13,000 acres of this land were appropriated for the improvement of Black River by the county court, and the work let to contractors. Some little work was done in cutting trees and removing drift-piles for a distance of twelve miles below Poplar Bluff, but the improvement was poorly executed for want of suitable superintendence. In 1867 another appropriation was made of 35,000 acres of the swamp-lands for the same purpose; 15,000 acres were patented to the contractor to provide his outfit, who chartered the steamer Nitronia, (138 feet in length, 24 feet beam, and 20 inches depth of flotation,) which succeeded in reaching Poplar Bluff, from which place the improvement was to commence. On account of some legal complications in which the contractor became involved, no work was done, and his contract abandoned.

On the remaining 20,000 acres the county has made a contract with two of its citizens to run a steamer to Poplar Bluff four times a year for five successive years, without requiring any improvement to be made. The contractors have built a boat at Poplar Bluff (72 feet in length, 20 feet beam, and drawing 18 inches) for the work. No improvement to the river can result from this contract.

The Missouri legislature of 1870 made an appropriation of $15,000 for the improvement of Black River in Missouri, contingent, however, on the condition that "a provision be made for similar improvement in Arkansas." Butler County has donated the remainder of her swamp-lands to railroads, and Arkansas has failed to make a provision whereby the $15,000 could be made available.

OBSTRUCTIONS TO NAVIGATION—IMPROVEMENTS AND COST THEREOF.

The principal obstructions to navigation are snags and overhanging trees. From Poplar Bluff to the Arkansas State line, a distance of sixty-eight miles, there were

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counted 2,977 snags and 4,618 overhanging trees. Between the limits of the examination, a distance of one hundred and sixty-eight miles, were counted 7,411 snags and sunken logs, and 10,122 overhanging trees.

The river is so narrow that trees, in falling into it from its banks, reach entirely across the stream, and are in the worst position for removal.

I do not recommend that any improvements be made on the shoals, other than removing snags, except on the three shoals mentioned as having rock bottom, where the channel might be advantageously widened and the depth increased.

As before stated, there are many sloughs and cut-offs, which, as they draw large quantities of water from the main river, should be closed up by dams. Commencing with a slough above Poplar Bluff, there are 14 places where dams should be built, involving an aggregate length of 1,200 feet. Low stone and brush dams would be well adapted for this purpose, but as stone can only be procured at great expense, "snag-dams," held in place by piles, will have to be resorted to.

These dams should not be built much above usual low-water mark, in order that the water during freshets may flow over them into the sloughs, and thus prevent the excessive overflow which would ensue should the water be confined to the main banks of the river.

There are five drift-piles in the river above the Arkansas State line, more or less obstructing navigation, and upon which some work should be done; also a wreck of an old stave-boat, which should be removed.

In operating for improvement upon streams the size of Black River, it being about three hundred miles from Poplar Bluff to its mouth, and its general width very narrow, it is of almost an absolute necessity to use a boat having some propelling power of its own, in order to place the snags pulled out of the way of passing steamboats. When such a boat shall have been furnished, I present the following estimate for improving Black River from Poplar Bluff to Pocahontas:

Pulling 7,411 snags and sunken logs, 20 months' work, at $3,000 per month	$60,000
Cutting 10,122 trees, at 50 cents per tree	5,061
Work on 5 drift-piles, and wreck of stave-boat	3,000
Pile-driver, delivered, (hand or animal power)	1,500
1,200 linear feet snag-dams, at $5 per foot	6,000
Work on rock shoals	5,000
	80,561
Add for engineering and superintendence	10,000
Total estimate	90,561

I am, general, very respectfully, your obedient servant,

A. H. BLAISDELL,
Civil Engineer.

General W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers, U. S. A.

TABLE OF SHOALS.

BETWEEN POPLAR BLUFF AND DAN'S RIVER, TEN MILES.

Name.	Length.	Channel in low water.		Remarks.
		Depth.	Width.	
	Feet.	*Feet.*	*Feet.*	
Henderson	600	2 to 4	40	Gravel and sand bottom; logs in channel.
	600	2 to 3	60	Sand bottom.
	300	3 to 4	30	Sand bottom.
	150	2.5	35	Gravel and sand bottom.
	300	2.6	35	Gravel and sand bottom.

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FROM HEAD TO MOUTH OF DAN'S RIVER, SIXTEEN MILES.

150	3	30	Bottom of snags, imbedded in sand.
150	3	35	
175	2.5 to 3	30	
250	2.5	30	
300	3	40	
220	3	40	Used as a ford.
100	3	30	
120	3	25	
75	2.5	40	All these shoals occur in bends; the river itself is very narrow in this locality.
100	2.5	30	
150	3	30	
300	2.5	40	
150	2.8	30	
150	2.5	30	
1,000	2.5	30	
400	3	30	
150	3	20	
600	3	40	
350	3	30	At mouth of Dan's River.

FROM MOUTH OF DAN'S RIVER TO GILLA'S BLUFF, SIXTEEN MILES.

100	3.5	50	
250	3.2	40	
400	2 to 3.5	40	
650	2 to 3	30	
150	2 to 2.5	30	
250	3	40	
1,800	2 to 3	90	In bend Roaring "cut-off."
300	2 to 3	90	
100	2.5	30	

FROM GILLA'S BLUFF TO ARKANSAS LINE, SIXTEEN MILES.

Name.	Length.	Channel in low water.		Remarks.
		Depth.	Width.	
	Feet.	*Feet.*	*Feet.*	
	350	3	30	
	300	2.8	40	
	200	3.3	35	Sand with muscle-shells.
	300	3.3	35	

FROM LINE TO LITTLE RIVER, THIRTY-ONE MILES.

200	3	40	Between these limits there is a general good depth of water.
75	3.5	30	
250	3	50	
100	2.3 to 3	40	

FROM HEAD OF LITTLE RIVER TO WAMICK'S POINT, THIRTEEN MILES.

2,400	2.5 to 3	30	In many of these shoals the bottom is overgrown by a species of grass which renders the bottom very hard.
250	2.5 to 3	40	
250	1.5 to 3.5	40	
300	3 to 4.5	50	
100	2 to 3	50	
200	1.5 to 3.5	50	

FROM WAMICK'S POINT TO SHAFFER'S HOUSE, EIGHTEEN MILES.

300	2.5	50
600	2.5	40
100	2.2	40

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FROM SHAFFER'S HOUSE TO CURRENT RIVER, TWENTY-FOUR MILES.

Cox's Ford	1,000	2	180	Fall .6 } rocky bottom.
Fish Trap	75	2.5	30	Fall .25 }
	300	2.5	50	
	150	2	30	
Rocky Ford	300	2 to 2.5	40	Rocky bottom, fall .25.
Russell's Ferry	450	3	60	Sand bottom.
	900	2 to 3	60	Sand and muscle-shells on bottom.

I 14.

BAYOU BARTHOLOMEW, FROM ITS MOUTH TO THE STATE LINE OF ARKANSAS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Missouri, March 28, 1872.

GENERAL: I have the honor to forward herewith the report of A. H. Blaisdell, civil engineer, of a reconnaissance of Bayou Bartholomew, from its mouth to the State line of Arkansas, made under my direction.

The estimated length of the portion of the stream examined is ninety-six miles, and boats of large capacity have navigated this portion of the river, and small boats have been up stream one hundred and thirty miles further. The river is an important and almost the only means of communication with quite a large district of cotton-growing country.

The proposed improvement of the Ouachita, if made, will have an important bearing on the navigation of Bayou Bartholomew, as the water at its mouth would be raised some 10 or 12 feet, which would give back-water for a distance of some forty miles.

The obstructions to navigation are similar to those in almost all the western tributaries of the Mississippi. The method of improvement proposed by Mr. Blaisdell is the same as was adopted on the Upper Ouachita and Little Missouri last season, and which has been recommended on almost all the streams examined, namely, to remove the snags and leaning timber. This is essential even if more extensive improvements should be made hereafter.

The estimate presented of $34,716 for doing the work is not above what it will actually cost.

Very respectfully, your obedient servant,

W. F. RAYNOLDS,
Lieutenant Colonel, Corps of Engineers.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

ENGINEER OFFICE UNITED STATES ARMY,
Saint Louis, Missouri, March 19, 1872.

GENERAL: I submit the following report on the recent examination of the Bayou Bartholomew, in the State of Louisiana:

The bayou takes its rise in the State of Arkansas, within five miles of Pine Bluff, on the Arkansas River, and following an exceedingly tortuous course flows, at first, parallel to the Arkansas River at an average distance from it of eighteen miles; then parallel to the Mississippi at distances varying from fifteen to twenty-five miles; and after striking the Louisiana line it diverges southwest and empties into the Ouachita River at Ouachita City, in section 16, township 20 north, range 4 east.

In Arkansas it flows through the counties of Jefferson, Drew, Desha, and Ashley, and in four of its sharper bends it touches the westerly edge of Chicot County; in Louisiana it traverses the parish of Morehouse.

From the Louisiana line to its mouth the principal tributaries of the Bayou Bartholo-

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mew are Overflow and Cheminahaut Creeks, both of which rise in Arkansas and enter the bayou on the right; on the left the tributaries are small bayous which drain the neighboring swamps, the principal of which are Bayous Bœuf, de Glaise, Bonidee, de Gallion, and Bonne Idee.

The total drainage area of the Bayou Bartholomew and its tributaries is about 1,800 square miles.

Following the meandering of the stream the distance from the mouth of the bayou to the State line is about ninety-six miles, while in a direct line it is 32.7 miles.

The bayou is very narrow, not averaging over 120 feet between banks; in many places it is considerably less.

In low-water season there are many places between the State line and Point Pleasant, a distance of about sixty-two miles, where the water varies from 2 feet to 10 inches in depth, and where the channel is not over 30 feet in width. Between these limits the bottom of the bayou is quite level, although there are a few deep pools. Between Point Pleasant and the mouth of the bayou there are 8 fords and shallow places, some of which are nearly half a mile long, on which the water s about 2.5 deep in the dry season, but the aggregate length of these shoals is less than that of the shoals above.

The bed of the stream is generally sand mixed with clay, but on some of the shallow places it is fine gravel and sand.

The stage of the water in the lower part of the bayou is controlled by that in the Ouachita River; back-water from the latter stream has reached Point Pleasant, a distance of thirty-four miles.

During the progress of the examination the water was 7 feet above low-water mark, and the velocity of the current, as determined at Point Pleasant, was nearly one and three-fourths miles per hour.

In 1843 navigation commenced on the Bayou Bartholomew to a considerable extent. Large steamers, having a carrying capacity of 2,000 bales of cotton, have reached the State line, and smaller steamers ascend the stream to a shipping point in Arkansas, called Gaster's Landing, about one hundred and thirty miles above the line by water and forty-six by land.

Between the Bayou Bartholomew and the Mississippi River are Bœuf River and Bayou Tensas, with its tributary, Bayou Macon. Bayou Tensas heads in Lake Providence, and the other streams rise in Arkansas, above Gaines's Landing.

I extract the following from the report (page 41) of the Delta survey in relation to these bayous:

"The gradual extension of the levee system upon the banks of the Mississippi has deprived this net-work of bayous of their chief supply of water, and they now never rise to the level of their banks except on the occurrence of many large crevasses in the Mississippi levees. Formerly this whole region was deeply inundated in floods. In 1828, when the greatest inundation of which there is even a tradition occurred, the average depth of water across the swamp, on the Louisiana boundary line, was 7.1 feet."

In 1850, another year memorable for its floods, there was a depth of water over the same line of 3 feet. The Delta report gives the profile of a surveyed line of a proposed railroad from Lake Providence to Fulton, which crosses the Bayou de Siard, a small bayou which connects the Bayou Bartholomew, near its mouth, with the Ouachita River; this profile gives the elevation of high water in the Mississippi at Lake Providence at 121 feet above the level of the Gulf; and of the banks of Bayou Bonne Idee 18.5 feet, of Bayou Bœuf 25 feet, of Bayou de Siard 24.5 feet, and of Ouachita River 23 feet below the level of high water.

During the late rebellion the levees at Lake Providence were cut, as a military measure, and they have not yet been repaired, so that it is probable that during the prevalence of continued floods in the Mississippi some of its water finds its way to the Ouachita River through Bayou Bartholomew.

I estimate the fall in water-surface between the line and the mouth of the bayou at 23 feet. The usual height between extremes of water is 23 feet.

CHARACTER OF ADJACENT COUNTRY.

In the valley of the Bayou Bartholomew we find two very distinct classes of soils; the first is the sand of the uplands, which is not productive enough for farming purposes, but on which a fair quality of pine timber is found, and, second, the low bottom-lands, which are distinguished for their being so well adapted for the production of cotton.

The tillable lands consist only of a narrow strip on each side of the bayou; beyond it are the low swamps, which are drained by the tributary bayous. The overflowed lands are largely in excess of the cultivated portion.

The bottoms are very productive, and may be relied on for producing, with a moderate amount of cultivation, one bale of cotton per acre; cotton is the chief, and, indeed, sometimes, the only product raised.

On the left bank of the bayou, for a distance of about twenty miles from the State line, is a range of low, broken hills bearing a growth of birch, sassafras, pecan, the

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different varieties of oak, elm, and some pine; on the bottoms are found gum, willow, sycamore, cypress, paw-paw, and other growth indigenous to that moist, tropical climate.

The highest banks of the bottoms are from 28 to 36 feet above low-water level, but one bank, at least, has two terraces, the lower of which is about 10 feet above the same level.

The parish of Morehouse contains, according to the last census, a population of 9,413 souls.

The towns and settlements along the bayou are as follows: Line, a hamlet on the boundary line between Arkansas and Louisiana, is a shipping point of some importance; it has a store from which is sold about $50,000 worth of merchandise annually.

Linn Grove contains a store and five houses; about $30,000 worth of goods is sold here annually.

Point Pleasant is the shipping point for Bastrop and surrounding country.

Bastrop, the parish seat of Morehouse, is situated on high sandy soil, about two and one-half miles east of the bayou, and contains about 650 inhabitants; it does a business in general merchandise of $150,000.

Between Bastrop and the bayou are the Bastrop Hills, the elevation of which, as given in the Delta report, is 40 feet above high-water level at Lake Providence.

The following is an estimate of cotton raised in and shipped from the adjacent country:

	Bales.
Line	3,000
Linn Grove	2,000
Point Pleasant and Bastrop	3,000
Sterlington and Morehouse Point, at mouth of bayou	1,000
Poplar Bluff, Arkansas	1,500
Plantations on bayou, about	1,000
Hauled to Mississippi River, about	500
Total	12,000

PREVIOUS IMPROVEMENTS.

Some twenty years ago good work was done on the Bayou Bartholomew by the "State hands" of Louisiana in cutting trees and removing snags, but it was not followed up.

In 1870 the legislature of Louisiana made a large appropriation for the improvement of Bayou Bartholomew, and some work was done in cutting overhanging trees between its mouth and a few miles above Point Pleasant. The contractor, after expending about $1,000, was informed that the appropriation was unconstitutional, as it was made when the State debt exceeded $25,000,000, which is the limit fixed by law.

This last work was poorly executed; large trees were allowed to fall into the bayou, and not cut up into such lengths as would allow them to float off.

OBSTRUCTIONS TO NAVIGATION—IMPROVEMENT AND ESTIMATES.

During high water the obstructions to navigation are principally snags, sawyers, and overhanging trees. I counted 1,296 snags and sawyers, and 1,878 overhanging trees which impede navigation, but as the examination was conducted during high water, the former number should be considerably increased. There are several islands in the bayou covered with small growth; this should be cut and removed for high-water navigation.

Navigation in the bayou generally opens between December 20 and January 27, and as no absolute dependence can be placed upon the water remaining high, planters are often compelled to ship their cotton and thus lose all the advantage of prospective rise in the market.

The steamboat pilots I talked with, as well as the people along the banks, seemed to think it feasible to make slack-water navigation in the Bayou Bartholomew; of this I cannot speak definitely, as it would require an accurate survey and a more thorough examination than I was able to give with the means at my disposal. The timber on the banks is mostly of that variety which sinks when green, and consequently it will have to be felled on the banks during low water and allowed to season, and if proper care is taken in cutting it into small lengths, high water will carry it off.

All that I can propose for improving the stream, as the results of my cursory examination, is to remove the snags and cut the leaning timber. Probably the most thorough manner of conducting this improvement would be to have a boat constructed to carry camp outfit and a hand-crane, which, in connection with animal power, could remove the snags to the banks, where they could be disposed of. The boat would have to be made smaller and of lighter draught than those used on the Ouachita last season.

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I present the following estimate for the improvement of the stream in Louisiana by this method:

EXPENSES FOR ONE MONTH.

Supervising engineer	$200
One mate and one foreman	250
Two cooks	150
Fifteen laborers, at $60 per month	900
Subsistence for 20 men, at $1 per day	600
Forage for 4 animals, at $1	120
	2,220
Building flat-boat	$600
Tools and rigging	1,000
Repairs of same	500
Four oxen	600
Removal of 2,000 snags and cutting 1,878 trees, 12 months' work	26,640
Add one month for passage down stream	2,220
	31,560
Add 10 per cent. for contingencies	3,156
Total	34,716

Good labor (colored) can be procured on the Bayou Bartholomew at the price named in the estimate, but probably it would be at a sacrifice to the planters of the vicinity; it is best, therefore, to hire acclimated laborers in some other near locality.

A light-draught snag-boat, with a moderate stage of water, could do excellent service in the Bayou Bartholomew, and would, probably, do all the work necessary for navigation at the stage of water boats usually ply the stream.

At Poplar Bluff, Arkansas, situated on the bayou, twelve miles (by land) above the line, there is a good saw-mill in operation, where lumber can be procured if the first-named method of improvement be adopted.

Very respectfully, your obedient servant,

A. H. BLAISDELL,
Civil Engineer.

General W. F. RAYNOLDS,
Corps of Engineers, U. S. A.

I 15.

FOURCHE LA FAIVE, ARKANSAS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Missouri, March 22, 1872.

GENERAL: I have the honor to forward herewith a report by Mr. Blaisdell, civil engineer, of an examination of Fourche la Faive, in Arkansas, made under my direction.

This stream seems to be little more than a mountain torrent, and I agree with Mr. Blaisdell that it is inexpedient, for the present, at least, to attempt any improvement above the town of Perryville. Between that point and the mouth there are five shoals; at one of them the width of channel is 40 feet and the depth 2 feet; at another the width is 30 feet and the depth 1 foot; at the other three the width of the channel at low water is only 7 or 8 feet, and the depth 6 inches. This statement is itself enough to show that even the lower section of the Fourche la Faive does not furnish water of itself to justify any attempt to make it navigable. The back-water from the Arkansas can, however, be relied upon, whenever that stream is 5 feet above its lowest stage, and it is only by regarding this fact that the Fourche la Faive becomes worthy of any consideration.

The fact that "no steamboat of larger dimensions than 42 feet in length and 10 feet beam has ever navigated the stream" goes far to show

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that even the back-water from the Arkansas is hardly sufficient to cause the Fourche la Faive to be fairly classed as a navigable stream.

The estimates of Mr. Blaisdell of $25,890, for cutting leaning timber and removing snags between the mouth and Perryville, seem to be fairly made, and the improvement, if completed, would doubtless be of considerable local benefit to the inhabitants of the country.

Very respectfully, your obedient servant,

W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Missouri, March 1, 1872.

GENERAL: I herewith submit my report on the recent examination of the Fourche la Faive, in the State of Arkansas.

The river rises in the extreme southern part of Sebastian County, within a few miles of the Choctaw reservation of Indian Territory, and, following a very winding course, flows in a general direction slightly north of east, traversing the counties of Sebastian, Scott, Yell, and Perry, and empties into the Arkansas River, twenty-five and a half miles above the city of Little Rock.

The upper part of the river, entirely through the first three counties, and through a portion of the fourth, is a wild mountain-stream, with numerous but entirely insignificant branches, which rise in the mountain-ranges, parallel to the river or their spurs.

The only tributary of any size is Grave Creek, or the South Fork of Fourche la Faive, as it is generally called, which empties into the main river from the south, about sixty-eight miles from its mouth.

On the north side of the Fourche la Faive, we find the range of Petit Jean Mountains and its spurs, called under different names, and on the south are the Mamelle Mountains and their spurs. From streams in a mountainous country, like the river under review, we expect, and are not disappointed in finding in the present instance, sudden "head-rises," produced by slight rains, but which are only of short duration.

The lower portion of the river in Perry County is controlled by the stage of water in the Arkansas; a rise of 6 feet in the latter stream backs the water up to the town of Perryville, a distance of twenty-six miles from the mouth of the Fourche la Faive.

In 1833 and 1844 there occurred extraordinary floods in the Arkansas River, the water standing at the locality under consideration, according to Mr. S. T. Abert, civil engineer, who conducted a survey of that stream in 1869, at the heights of 35.75 and 34.25 feet, respectively, above low-water mark. Both of these rises produced back-water in the Fourche la Faive to its junction with its south fork, sixty-eight miles from its mouth. At this point the difference of level between high and low water marks, as measured in 1844, was 32 feet. This difference may be regarded as maximum, and only attained when both the rivers are unusually high; usual high water in Fourche la Faive is 25 or 26 feet, and only of short duration. When all preliminary matters to the examination of the river had been arranged, a rain occurred of about 15 hours' duration, which caused the river to rise 8 feet, and the examination was conducted between the limit of back-water, the mouth of South Fork, and the mouth of the river, while the water was about 11 feet above low-water mark.

I give below the shoals between these limits in tabulated form:

From South Fork to Perryville, forty-two miles.

Name of shoals.	Distance from South Fork.	Length.	Channel in low water.		Fall.	Remarks.
			Depth.	Width.		
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
Apollo	0	250	0.5	30	1.0	Bottom of large loose rock, water-worn, with fine shales, gravel, and clay, cemented together.
Old Mill	3½	150	0.5	.....	0.6	
Lee	6	80	0.5	.....	.....	
Pope	7	100	1.0	.....	.....	
Smyers'	10	125	1.0	.....	.....	

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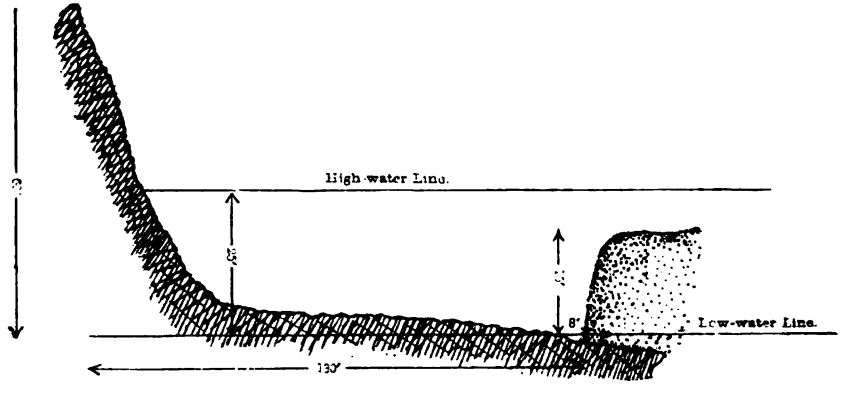
From South Fork to Perryville, forty-two miles—Continued.

Name of shoals.	Distance from South Fork.	Length.	Channel in low water. Depth.	Channel in low water. Width.	Fall.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
Buck	13	150	0.5	.....	.....	Bottom of large loose rock, much waterworn, with fine shales, gravel, and clay, cemented together.
Rock Creek	18	1,400	0.8	30	3.5	
Holcomb	19	150	1.0	.....	.....	
Watson's	22	250	1.0	20	0.8	Shaly rock outcrops from low bluffs on right bank, runs inclined across the river, leaving narrow channel on left.
Kendrick	22½	150	2.0	.....	0.3	Shaly rock bottom.
Houston's	25	230	2.0	20	0.4	Shaly rock bottom, inclining from low bluff on right, where shale outcrops.
Harrison's	27	350	1.5	10	0.5	Island 350 by 100 feet, covered with small growth, occurs, leaving the narrow channel on left compacted gravel bottom.
Cook's	30	1,200	0.2 to 3	20	2.3	This shoal consists of three shoals proper, 50 feet long, with a depth of water on them 2 inches, including between them two pools, having a depth of from 2 to 3 feet; bluff on right 50 feet high, with unconformable shale outcropping.
Clengelheifer	37½	250	2.5	40	0.3	Gravel bottom, with rock distributed.
Luntz's Ford	38	1,500	0.5 to 1.5	25	2.0	Same general remarks as on Cook's Shoal.
Lower Ford	40	250	1.5	60	.....	High sandstone bluff on right; bottom of large rock and shaly gravel.

Shoals below Perryville.

Name of shoal.	Distance from Perryville.	Length.	Low-water channel. Depth.	Low-water channel. Width.	Remarks.
	Miles.	*Feet.*	*Feet.*	*Feet.*	
Alford	5	650	0.5	8	Shaly bluff on right, 50 feet high; bottom of shale.
May's Ford	9	80	2.0	40	Gravel bottom; low banks.
Piney Point	12	900	1.0	30	Low bluff on point; shale rock bottom.
Indian Grave Ridge	13	450	0.5	7	Low bluff on right, with shale outcropping; shale rock bottom.
Red Ferry	20	1,530	0.5	8	Bluff on left, with shale outcropping; shale rock bottom, with large bowlders distributed over the whole width of river.

A general section of the last-named shoals may be well represented by the following sketch of Alford Shoals, except that in the Red Ferry Shoals the shaly bluff is on the left bank of the river.



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In low water there is a depth of water in the pools of from 3 to 8 feet or more. With a moderate stage of water, the current in the pools is very slow; but on the shoals it is very rapid. The width between banks varies from 80 to 140 feet, the river in its upper part being generally wider than it is below.

The banks are clayey and not subject to caving. No steamboat of larger dimensions than 42 feet in length and 10 feet beam has ever navigated the stream. Before the war flat-boats were floated out of the river with country produce, and on one occasion, when both the Arkansas and the Fourche la Faive were very high, a flat-boat, carrying a few bales of cotton, was successfully floated out from Bluffton, a small hamlet in Yell County, about 90 miles from the mouth of the river.

CHARACTER OF THE ADJACENT COUNTRY.

The valley of the Fourche la Faive, averaging about one mile in width on each side of the river, is a very fertile one, although it does not contain the population which its fertility merits.

The bottom-lands generally exhibit two terraces, or levels, the lower of which is overflowed during high water, and is only used as a stock-range; the upper and cultivated level is intersected by frequent spurs of the ridges parallel to the river.

The valley grows wider above Bluffton, on the eastern edge of Yell County, where the hills on each side strike the river.

Some of the bottom-lands in the vicinity of the Arkansas River are overflowed in extreme high water, but are cultivated to a considerable extent.

La Fourche Bluff, referred to in Mr. Abert's report on the Arkansas River, accompanies the Fourche la Faive up for over a mile from its mouth, on the south side.

For every few miles on the south side a bluff, with either sandstone or unconformable shales outcropping, strikes the river. On the opposite side of the river, bluffs are of much less frequent occurrence.

All kinds of timber are found in the valley and on the mountains, except poplar. About 1,200,000 feet of cypress and pine are annually rafted out of the river in logs. The river affords excellent water-power privileges; but at present there is only one water-mill on the stream.

In Perryville there is a steam-mill, which supplies all the lumber required in Perry County.

The principal farming products raised in the valley are stock, cotton, and corn. From 6,000 to 8,000 bales of cotton are annually raised in Perry County, and the greater portion of this amount, and what is raised in the upper valley, is hauled in wagons over the mountains and through the valley of the Petit Jean River to Dardanelle, for market, a distance varying from about thirty to over one hundred miles, and the remainder is carried to Brown's Landing, about fifteen miles from Perryville, on the Arkansas River, for shipment.

Perry County contains 650 taxable inhabitants. The only town on the river deserving mention is the county-seat of Perry, Perryville, twenty-six miles from its mouth. It contains a population of about 100, and sells $40,000 worth of merchandise yearly.

OBSTRUCTIONS TO NAVIGATION—IMPROVEMENTS, AND ESTIMATED COST.

The obstructions to navigation during high water are leaning timber and snags. From its junction with South Fork to its mouth, the river contains 1,691 snags, and there are 8,480 trees overhanging its banks, obstructing navigation; but, since the examination was conducted during high water, the former number should be considerably increased. From Perryville to the mouth of the river there were counted 754 snags and 4,132 trees, of an average diameter of 1 foot. In making the improvement of the river, owing to its small width, the trees will have to be felled on the banks and cut up into small lengths before they will float out at high water, and not form drift-piles.

I do not deem it advisable, owing to the primitive state of the country, to make any improvement farther up than Perryville.

It would be impossible, without slack-water navigation—and there seems to be a doubt whether the stream affords enough water in the low-water season—to make the river navigable, with certainty, during any portion of the year above the mouth of South Fork.

Between the mouth of South Fork and Perryville there is an excellent wagon-road on the second bottom, and this distance of sixteen miles would not materially increase the cost of hauling when cotton is the shipment.

Were this improvement effected, the cotton in the upper valley would, I think, find its way to Perryville.

The distance from Perryville to Brown's Landing, on the Arkansas, is only about fifteen miles, but it is through a low, swampy country, making a very laborious haul.

In making this improvement I propose using a flat-boat, carrying a hand-crane, with

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an outfit of tools and rigging for pulling snags and cutting trees, entirely similar to those used on the Upper Ouachita and Little Missouri Rivers last season.

The monthly cost of running such a boat would be:

Supervising civil engineer	$200
Mate	150
Foreman of wood-choppers	100
Fifteen laborers, at $60 per month each	900
Subsistence of 20 men, at $1 per day	600
Two cooks	100
Total	2,050

Estimate of cost for pulling snags and cutting trees from Perryville to the mouth of the river:

Building flat-boat	$600
Outfit of tools and rigging	1,000
Repairs of tools and rigging	500
Removing 1,200 snags and cutting 4,132 trees, 9 months' work, at $2,050 per month	18,450
Add ½ month for passage of boat down stream	1,025
	21,575
Add 20 per cent. for contingencies	4,315
Total	25,890

By the expenditure of this sum the river would be made navigable up as far as Perryville, for that portion of the year when the Arkansas is high, lasting about eight months, which time would be amply sufficient for the people to ship their farming produce and secure their yearly supplies of merchandise.

It is proper to state, before conclusion, that a small steamer, the Danville, was built with a special reference to the Fourche la Faive and Petit Jean Rivers, and at last accounts had entered the latter stream, but with what progress I have not learned.

I am, general, very respectfully, your obedient servant,

A. H. BLAISDELL,
Civil Engineer.

General W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers, U. S. A.

I 16.

EXAMINATION AND SURVEY OF CUIVRE RIVER, IN MISSOURI.

OFFICE WESTERN RIVER IMPROVEMENTS,
Saint Louis, Missouri, October 3, 1871.

GENERAL: I have the honor to forward herewith the report of Mr. A. H. Blaisdell, civil engineer, of his examination of Cuivre River, in Missouri.

Notwithstanding a small steamer once reached Moscow Mills, Mr. Blaisdell considers the cost of making the portion of this stream between that point and Big Creek (a distance of about nine and one-half miles) navigable so great as to render it virtually impracticable, an opinion in which I fully concur, and in which I am satisfied the Department will coincide on reading his description of it.

The estimated cost of improving the stream from the mouth to within one-quarter of a mile of Big Creek, a distance of about eighteen miles, is as follows:

To give a depth of 4 feet	$33,677 50
To give a depth of 6 feet	60,065 00

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Mr. Blaisdell says: "By far the strongest argument in favor of the improvement of the river is the opening it would afford for the coal and iron of Lincoln County to find a market."

In considering this argument it should be remembered that the "coal and iron of Lincoln County," in order to reach Big Creek, must be placed on railroad-cars and transported by rail from the mines—distances varying from fifteen to thirty miles; that when it reaches that point it will be already on the cars, with a railroad (now being constructed) ready to carry it to the Missouri River, a distance of not exceeding twenty miles farther, and that once on the Missouri there would always be water-navigation to transport it wherever desired. With this fact in mind, I think the Department will agree with me in my conclusion that this stream is not one which should be improved by the General Government.

Very respectfully,

W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

OFFICE WESTERN RIVER IMPROVEMENTS,
Saint Louis, Missouri, August 30, 1871.

GENERAL: Having been assigned to the charge of the examination and survey of the Cuivre River, Missouri, from its mouth to Moscow Mills, by orders from this office dated August 5, I immediately proceeded to the latter place, procured a skiff in which I passed over the river between the limits named, and completing the examination on the 16th instant, have the honor to present the following report in connection with the accompanying map.

The river is formed by the confluence of what are termed the North and West Forks of the Cuivre River, the former taking its rise in Ralls and the other in Audrain County, in the northeast quarter of section 14, township 49, of range 1 west, of the fifth principal meridian. Both forks are augmented by numerous small streams, or creeks, which, flowing from the high bluffs of the adjacent country, scarcely merit the name of creeks in time of low water, but during freshets become turbulent in their character, and carry considerable sediment into the stream to which they are tributary.

The general direction of the flow of the Cuivre River is southeasterly until it enters section 31, in township 48, range 2 east, where it receives its principal tributary, Eagle Forks, or Big Creek; thence it flows northeasterly, emptying into the Mississippi River in section 9, township 48, range 3 east. These directions are, however, only general, for the river pursues a very winding and tortuous course, making many sharp bends and turning many short elbows. The river and Big Creek form the north and south boundary line between Saint Charles and Lincoln Counties. In the lower part of its course the river is scarcely more than a slough of the Mississippi, as witnesses the fact that for fifteen miles from its mouth no current is discernible, and that corresponding rise and fall in the water-surface is observable in accordance with the stage of water in the larger river. The total drainage area of the Cuivre River and its tributaries is estimated at one thousand five hundred square miles.

The country traversed by that portion of the river which was examined, a distance of twenty-eight miles, is essentially a farming one; is thickly settled, and kept in a high state of cultivation. The principal farming products are tobacco, wheat, and other grains, fruit in large quantities, and cattle. The lands immediately adjacent to the river are principally bottom-lands; sloughs are of frequent occurrence, which often embrace between the river and themselves several hundred acres.

From Moscow Mills down to Big Creek the bottom-lands on the right are only a few hundred yards wide, and are bordered by uplands, which, in several places, strike the river and accompany it for short distances. These bottom-lands vary from 8 to 16 feet in height, and are annually overflowed to the depth of 16 to 8 feet; they are covered with a fine growth of timber, consisting generally of burr-oak, Spanish or water-oak, elm, maple, bass, pecan, cottonwood, willow, sycamore, and black walnut. A large business is annually done in timber and cord-wood, especially the latter, which is piled in large quantities along the banks, awaiting high water for shipment. The banks of

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the river generally stand at a slope of 1½ or 2 on 1, unless in the sharper bends, where they show evidences of annual wear.

Coal and iron largely abound in Lincoln County, in the range of township just north of that containing the river, and both minerals have been mined to a small extent. The coal is found in seams varying from 6 to 15 feet in thickness; is of excellent quality, remarkably free from sulphur, and trial has shown it to be specially adapted for the production of gas. The coal strata outcrop in many places, and are generally mined by adits from the hill-side or from creek-bottoms. It is principally worked at present in sections 2, 11, 14, 23, and 26, township 49, range 1 west; sections 27, 29, 34, and 36, township 49, range 2 west; section 1, township 48, range 1 west, and in that tier of sections for twelve miles westward. A company known as the "Lincoln County Coal and Mining Company" are proprietors of 5,000 acres of the coal-tract, and are making extensive preparations for carrying on the business largely as soon as the question of transportation becomes settled. The iron ore is the brown hematite variety; it has not been so largely worked as the coal, but is now looming up into importance. It has been found in workable quantities in sections 1, 2, 3, 4, &c., township 49, range 2 west; sections 34 and 35, township 50, range 2 west; and sections 32 and 33, township 50, range 1 west. A company have leased 3,000 acres of iron-lands, and intend to commence operations soon on a much more extensive scale than at present.

The question of internal improvements has been, during the past few years, agitated to a great extent in Lincoln and adjacent counties, and has resulted in the building of the Keokuk and Saint Louis Railroad by county subscription. Nine miles of grading have been finished in Lincoln County; eleven are under contract and will be finished in the early part of next month. The road as in process of construction between Moscow Mills and Big Creek is laid down on the map. The location of the road in Saint Charles County has not been finished, but it departs from the river as it enters the county and intersects the North Missouri road at some point not yet definitely determined, but probably at the city of Saint Charles. In passing over the river I found such a difference existing in the obstructions met with, and in the general character of the stream between Moscow Mills and the mouth of Big Creek, and from the latter place to the mouth of the river, that I have divided the description of the river in these two divisions.

During the progress of the examination the river was at as low a stage, within a few inches, as ever known, and all soundings are referred to low water.

FROM MOSCOW MILLS TO BIG CREEK.

Moscow Mills is a small hamlet, and is only worthy of notice on account of the grist-mill in operation there. A water-fall of 8 feet is procured by a wooden dam thrown across the river at this point. The maximum capacity of the mill is 20 bushels per hour, but in times of low water the mill uses more water per day of twelve hours than the river supplies, while running but half of the above maximum.

In moving down the river from Moscow, no less than eighteen shoals and narrow passages were encountered between that point and Big Creek, a distance of nine and a half miles. The shoals were generally above low-water mark, while in the narrow channel were a few inches of water, but not sufficient to float our boat. The fall in the water-surface over these shoals varied from 3 to 15 inches.

Snags were of very frequent occurrence, and on two occasions we were completely shut off from communication below by piles of drift-wood and snags, which had to be partially removed before further progress could be made. For a large portion of the distance, numerous overhanging trees were met with, which would impede navigation were it ever attempted.

On several occasions we also encountered islands of quite large extent, situated directly in the middle of the river, with narrow passages, with little depth of water, on each side. Two of these islands were 600 feet long and about 90 feet wide, covered with large trees, smaller vegetation and snags, and from 8 to 12 feet above low-water mark. A few deep holes were encountered, however, in which the water was from 4 to 12 feet deep, but for no great distance.

As no continuous line of levels was run, I examined the notes of the Keokuk and Saint Louis Railroad, and found the difference of level between high-water marks at Moscow Mills and at the mouth of Big Creek to be 15.8 feet. Relying on the statements of residents in these two places, I found the difference of level between high and low water marks at the former place to be 24.4 feet, and at the latter 25 9, which gives the fall in water-surface between these two places, a distance from each other nine and a half miles, 17.3 feet. In this portion of the river were counted 928 snags and sawyers or fallen trees, most of them lying in the channel.

In view of these facts, improvement of the river between Moscow Mills and Big Creek is impracticable, as the business of this portion of the river is not commensurate with the enormous cost which would result if improvement were attempted. No estimate is therefore made for improving this portion of the river.

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It might be stated before conclusion that, several years ago, a small steamer found its way to Moscow Mills, but at a sacrifice of her chimneys and upper works in returning, and escaping only after great difficulties from remaining there until the recurrence of high water.

FROM BIG CREEK TO THE MOUTH OF THE RIVER.

Between these limits, a distance of eighteen and a half miles, the river is much better in its general character and depth of water, and but little fall in the surface of the water occurs, not exceeding 1½ feet.

At the mouth of Big Creek occurs a bar. Its dimensions are 850 feet in length, 190 feet wide, extending over the whole width of river, and a fall of 0.3 foot occurs in the water-surface. Its material is coarse gravel, which has been brought down by Big Creek, a stream which is susceptible to sudden rises, and passes from a sluggish creek into a torrent in a few minutes.

Passing down the river we find a good depth of water, varying from 4 to 8 feet, until we reach a shoal one and three-quarter miles from Big Creek. This shoal extends over the whole width of river, with an average of 2 feet of water upon it, and is 350 feet in length. There is no apparent cause for the formation of this bar, unless it be from snags, a few of which are visible, and from the bends in the river below.

Continuing on, with from 5 to 11 feet depth of water, we reach White's Branch Bar, three and a half miles from Big Creek. This shoal is a very serious obstruction to navigation, and on it occurs the only great fall in water-surface in the lower portion of the river. Its length is 800 feet. The form of this bar is peculiar, it being divided into two portions by the narrow channel, which crosses it diagonally. The cause of this bar can be traced to a small creek, called White's Branch, which, flowing from the high bluffs back of the river in time of freshets, carries with it the coarse gravel of which the bar is composed.

From 6 to 10 feet depth of water was then met with until we reach a settlement called "Chain of Rocks," four and a quarter miles from Big Creek, where two bars were found. The first bar is 300 feet long, 130 feet, or width of river, wide, with an average of 1.2 feet depth of water upon it. A snag was probably the primary cause of this bar. Then ensues a depth of water of from 5 to 9 feet for 750 in length, when we reach Seed-Tick Island Bar, caused by a small island 300 feet long and 60 feet in width, which, by diminishing the width of the river, prevents the free egress of the water above, and forms the bar. The length of this shoal is 1,200 feet, with an average of 1 foot of water upon it. At this point I obtained an iron bar, and sounded for rock underneath the gravel, but found none in several soundings to the depth of 3 feet below the gravel-surface.

At eight and a half miles from Big Creek, we came to a hamlet called Monroe, containing a store and hotel, having met with an average of 6½ feet depth of water from Chain of Rocks.

At half a mile from Monroe was encountered a small bar, only 30 feet in length and extending entirely across the river, and which probably owes its origin to a snag; one-quarter of a mile farther on, a wrecked barge was met with, lying near the channel, and requiring removal. No other obstructions were encountered until at ten and three-quarter miles from Big Creek, when we reached the Ensaw or Shelton Bar. This shoal is 650 feet long, width of river, or 130 feet, wide, with an average of 1.8 feet of water upon it, and is situated directly in a bend of the river.

One-half mile below Shelton Bar we came to another shoal, 250 feet long, 130 feet, or width of river, wide, with 2.5 feet average depth of water upon it. Thence to the mouth of the river no other shoals were met with; the water varying from 6 to 12 feet in depth.

In the lower portion of the river, the shoals which I have just described were counted—four hundred and ninety-four fallen trees, sawyers, and snags; most of these obstructions were, however, along shore, and not in the way of navigation, and only a small proportion of the number will require removal.

The Cuivre River empties into the Mississippi through a slough, included between Cuivre Island and the main land, through which boats have to pass to reach the river.

In the slough, going south from the mouth of the river, a general good depth of water is met with on the concave side of the bends, but the crossings, of which there are three, have but little water upon them, varying in depth from 0.5 to 2.5 feet. Another bar is found at junction of the slough and river.

The upper part of the slough contains one bar, but another exists at the head of Cuivre Island, at the entrance into the slough.

In the lower part of the slough were counted twenty-four snags, and in the upper sixty-five, only a few of which, in the channel, are required to be removed.

Notwithstanding the numerous obstructions to navigation, the commerce of the Cuivre River is considerable. The steamer Josephine, having the following dimensions, length 110 feet, 20 feet beam, 3½ feet depth of flotation when loaded, and a ton-

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nage of 125 tons, was built with a special reference to the Cuivre River trade, and makes regular trips whenever the stage of water will allow.

In the year 1869–'70 boats ran to Chain of Rocks from April to December, making often two trips a week; during the present year the depth of water only permitted them to run from March to July.

Chain of Rocks is the principal shipping-point for farmers in that vicinity; two freighting firms in the place, in connection with two variety-stores, do an annual business varying from $24,000 to $32,000. At Monroe considerable traffic is also carried on.

It is difficult to determine, with any degree of exactness, what the shipments on the river do amount to, as they are made at such places along the bank as are most convenient to the farmers for hauling their produce.

Were the river improved, the amount of commerce would be materially increased, as much of the freights which now find their way to Cap-au-Gris, on the Mississippi, would be hauled to the banks of the Cuivre, could reliance be placed upon their early shipment. One hundred tons a week, for six months of the year, would not, I think, be too large an estimate for the prospective business at Chain of Rocks alone.

But by far the strongest argument in favor of the improvement of the river is the opening it would afford for the coal and iron of Lincoln County to find market.

In order to successfully bring these minerals of this region into competition with those from other localities, it becomes necessary to have cheap rates of transportation, or, in other words, water-communication, and this can only be obtained through improving Cuivre River.

Were the improvement effected, barges might be loaded with the minerals at the mouth of Big Creek, which had been brought down from the mines on the Keokuk and Saint Louis Railroad, and thence taken to any point on the larger western rivers.

The only inland town which would be greatly benefited by the improvement is Troy, the county-seat of Lincoln County, which has a population of about 1,000, and does an annual business of $245,000.

Below I give the bars in the order they occur, from the mouth of Big Creek, with an estimate of the material required to be removed from each, to give a depth of water of 4 and 6 feet respectively, at the lowest stage, with a width of channel of 80 feet, the effect of the falls in the water-surface which would result from the removal of White's Branch Bar being taken into account:

Name of bars.	For 4 feet of water.	For 6 feet of water.
	Cubic yards.	*Cubic yards.*
Big Creek	14,615.0	20,671.0
No name	4,560.0	6,980.0
White's Branch	8,340.0	11,807.0
Chain of Rocks	2,646.0	4,991.0
Seed-Tick Island	8,466.0	18,566.0
No name	110.0	288.0
Ensaw or Shelton	4,468.0	8,546.0
No name	1,143.0	2,820.0
Total	44,348.0	74,669.0

I made the estimate for securing 6 feet depth of water, since the mining companies wish to use, in transporting their coal and ore, barges drawing from 5½ to 6 feet of water; with this depth, however, there exists the probability of striking rock in several places, especially at the place marked on the map as Cat Fish Rock, where the river was found to have a rock-bottom at a depth of from 5 to 6 and 10 feet; and as this point is above White's Branch Bar, the removal of which would cause a decrease in height of the water-surface above it of one foot, some rock would require excavation.

The material of all the bars, except the Shelton, and the small one below it, is very coarse, compacted gravel; the two latter bars are composed of finer material.

I present the following estimate of cost for improving the river by dredging the bars, removing snags, and also provide for an accurate survey of the river, and for engineering superintendence during improvement.

1. *For 4 feet depth of water on bars.*

Dredging and removal of 38,737 cubic yards of coarse gravel, at $1 per cubic yard $38,737 00

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Dredging and removal of 5,611 cubic yards of fine gravel, at 50 cents per cubic yard	$2,805 50
Seven days' work of snag-boat	750 00
Dredge-boat in slough five days	500 00
Survey of river	1,500 00
Engineering expenses during improvement	4,000 00
Total	48,292 50

2. *For 6 feet depth of water on bars.*

Dredging and removal of 63,303 cubic yards of coarse compacted gravel, at $1 per cubic yard	$63,303 00
Dredging and removal of 11,366 cubic yards of fine gravel, at 50 cents per cubic yard	5,683 00
Snag and dredge boats	1,250 00
Survey of river	1,500 00
Engineering expenses during improvement	5,000 00
Excavation of rock, say	4,000 00
Total	80,736 00

These figures provide for the improvement of the river as far as Big Creek.

The interests of the country adjacent to the river do not actually require the removal of the Big Creek Bar, from the fact that, with a small expenditure, the railroad-switch could be carried below the bar, and the river would still subserve all the purposes of the coal and iron companies.

If this bar should not be removed, the estimate would be reduced as follows:

For 4 feet depth of water, reduction of	$14,615 00
For 6 feet depth of water, reduction of	20,671 00

Leaving the estimate as below:

For expenses incurred in making the river navigable to within one-fourth of a mile from mouth of Big Creek, with 4 feet depth of water	$33,677 50
With 6 feet depth of water	60,065 00

In regard to the permanency of the improvement by opening the channel with a dredge, it is my opinion that, if a proper angle be given to the slopes of the channel, a number of years will pass before further dredging is required.

By damming such streams as the White's Branch a short distance back from its mouth, a large proportion of the sediment could be kept out of the river.

A small annual expenditure will be necessary to keep a channel open in the slough; a few days' work each year being sufficient to accomplish this result.

I am, general, very respectfully, your obedient servant,

A. H. BLAISDELL,
Civil Engineer.

General W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers, U. S. A.

EXAMINATION OF CURRENT RIVER, FROM ITS MOUTH TO VAN BUREN, MISSOURI.

OFFICE WESTERN RIVER IMPROVEMENTS,
Saint Louis, Missouri, December 8, 1871.

GENERAL: I have the honor to submit the following report upon the examination of Current River, from its mouth to Van Buren, Missouri, made under your instructions, and in compliance with the act of Congress approved March 3, 1871:

For some time after this duty was assigned to my charge I was unable to procure a competent engineer to take the immediate charge of the work, but at length secured the services of Mr. A. H. Blaisdell, who made the examination, and from whose report to me the data herein are

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derived. Current River rises in Texas County, Missouri. It flows through Shannon, Carter, and Ripley Counties in Missouri, and Randolph County, Arkansas, and discharges, through Black and White Rivers, into the Mississippi. Its general direction is southerly, but in the lower portion is very tortuous. Its waters are pure and limpid. The principal tributaries above Van Buren are Jack's Fork, Blair, and Pike Creeks; below Van Buren, Big Barren, Buffalo, Little Barren, and Brier Creeks, in Missouri, and Little Black River in Arkansas. The area drained by the stream and tributaries is estimated at a little over two thousand square miles.

In addition to the tributaries, there are numerous large springs near Van Buren, which add largely to the volume of water. A rough gauging of the largest showed a discharge of over 500 cubic feet per second, or nearly one-third of all the water in the stream immediately below it.

The direct distance from the mouth of the stream to Van Buren, as measured on the map, is about fifty miles; to the State-line, eighteen miles. These distances, by the channel, are respectively ninety-two and forty miles.

The ordinary high-water mark is 12 or 13 feet above the lowest stage, though it is said to have risen 25 feet in 1812 or 1813. The width of the stream, with the exception of a few narrow points, is from 180 to 250 feet. The bed is fine shifting gravel.

Steamboats which navigate Black River ascend Current River to the mouth of Little Black, about thirty miles, and the latter stream a short distance, whenever there is freight to pay them for doing so.

In Missouri the country adjacent to the stream is very hilly, the bluffs forming one of the banks; a low bottom, subject to overflow, the other. Near the State-line the bluffs disappear, and the country becomes more level.

The hills in Missouri contain iron, lead, zinc, and other metals, but none of them have been worked to any extent, owing mainly to the want of transportation.

POPULATION AND PRODUCTS OF THE COUNTRY.

The population in all this region is sparse. Carter County contains over four hundred and fifty square miles, and only three hundred and sixty-five taxable inhabitants. Van Buren, the county-seat, is a small hamlet, but has a store said to do a business of $20,000 annually.

Ripley County, Missouri, embraces an area of over six hundred square miles, and only six hundred and eighty-two taxable inhabitants. Doniphan, the county-seat, has one hundred and twenty-three inhabitants, but is said to do a business of $50,000 annually.

Pittman is a small settlement on the State-line. A store here reports an annual business of $22,000. There is a cotton-gin at this place, and 240 bales of cotton were shipped here last year.

Shumacker's is a settlement sixty-nine miles below Van Buren, where a cotton-gin is being erected. It bids fair to become quite a business point.

D. C. West owns a cotton-gin and steam saw-mill, located eighty-three miles below Van Buren; 400 bales of cotton were shipped from this point last season, and a store reports an annual business of $20,000.

It is difficult to estimate the amount of cotton raised in the country, as much of it is carried to Pocahontas on the Black River for shipment.

The lumber interest is at present the important one of the region; numerous small saw-mills, on or near the stream, manufacture the fine

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yellow pine of the neighboring hills; 1,000,000 feet of lumber and 500,000 feet of logs have been the annual average export for the past three years.

SHOALS AND OBSTRUCTIONS TO NAVIGATION.

Between Van Buren and the mouth of the river there are ninety-four shoals, only three of which have as little as 1 foot of water on them. Fifteen have more than 1 foot and less than 2 feet upon them at the lowest stage, while the remainder vary from 2 to 3 feet in depth. Thus, by improving less than twenty places, we would have a depth of 2 feet at all stages, and, by improving only three, would, at all times, have a depth of 18 inches.

Some of the shoals are caused by islands dividing the river into two or more channels. They would be improved by closing all the channels but one with low-water dams. One of the worst places on the stream has been caused by Kittrill's dam, made for milling purposes; its removal is required if the navigation is to be improved. The fact that the building of this dam has been permitted shows the low estimate that has heretofore been put upon this stream as a means of communication.

The other obstructions to navigation are snags and leaning timber. It is estimated that seven hundred snags and six hundred leaning trees should be removed.

PREVIOUS SURVEYS AND IMPROVEMENTS.

In the year 1857 an approximate compass-survey was made between Jack's Fork, thirty-four miles above Van Buren, and the State line. The fall was estimated at 133 feet between these points, a distance of eighty-six miles.

As the fall is more rapid above than below Van Buren, the descent from that point to the State line can probably be fairly estimated at 50 feet from the State line to the mouth. The fall is about 10 feet, or approximately 60 feet for the whole distance of about ninety miles.

As far back as 1855 the State of Missouri appropriated $10,000 for the improvement of the Current River. The first expenditure was in 1857, when some snags were removed and timber cut, but the work not having been judiciously done, no permanent good was effected.

The rebellion prevented the further prosecution of the work until 1870, when a contract seems to have been made to have the steamer Malta (length 90 feet, beam 18 feet, and drawing 22 inches) ascend the river to a point twenty-three miles below Van Buren, the idea being, apparently, that it would be necessary to improve the navigation to comply with the contract, but the feat was accomplished by the usual method of "sparring," when the owner transferred her machinery to a flat-boat, and left the hull to mark the "head of navigation."

At the last session of the legislature of Missouri a bill was introduced appropriating $20,000 for the further "improvement" of the stream. It is said there is a prospect of the appropriation being made by the legislature now in session.

PROPOSED IMPROVEMENTS.

The expense of improving this stream will, of course, depend largely upon the nature of the work proposed. In any event, the removal of the snags and leaning timber will be required, and that much should be

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done. This, with the improvement of some of the shoals, by low wing-dams, to throw all the water at low stages into one channel, would probably be all that the present development of the country demands. This work could probably be performed at comparatively little expense by the use of a flat-boat, provided with steam-power, for pulling snags, and a party to cut trees, as has been successfully done the past season on the Ouachita.

To deepen all the shoals would require the use of a dredge-boat and the expenditure of a larger amount of money than would be justified by the present demands of commerce. Should the future development of the country call for a lock and dam navigation, it can doubtless be made, but before making the estimate a more careful survey would be necessary than we have been able to make.

ESTIMATES.

The estimates for the proposed improvements are as follows:

Monthly cost of running the crane-boat:	
Supervising engineer	$200 00
Mate	150 00
Engineman	150 00
Cook	60 00
Second cook	45 00
Ten laborers, at $60 per month	600 00
Subsistence of fifteen men, at $1 per day	450 00
	1,655 00
Building crane-boat	$6,000 00
Outfit of tools	1,000 00
Repairs of tools	500 00
Removing 701 snags, five months' work, at $1,655 per month	8,275 00
Building 1,800 linear feet of stone and brush-dam for cutting of chutes, two and a half months' work, at $1,655 per month	4,137 50
Cutting 600 trees	300 00
Removing Kittrell's dam	500 00
Add one month for passage down stream	1,655 00
	22,367 50
Add 15 per cent. for contingencies	3,355 12
Total	25,722 62

Yours, respectfully,

W. F. RAYNOLDS,
Lieutenant-Colonel, Corps of Engineers.

APPENDIX K.

ANNUAL REPORT OF MAJOR W. E. MERRILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

CINCINNATI, OHIO, *June* 30, 1872.

GENERAL: I have the honor herewith to submit the annual report for the works under my charge, for the fiscal year ending June 30, 1872. I have had the direction of the works herein reported throughout the year, the principal work being the improvement of the Ohio.

Our working season on the Ohio usually begins on or about the 1st

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of June, as before that time the river is generally too high to permit economical prosecution of river work, and hence by the time these reports reach Congress they are generally a working season behind, and thus there is always more work actually completed before the next appropriations are made than has been officially reported. It seems right to keep this fact before Congress, otherwise it may be assumed that but little has been accomplished, when, in fact, a great deal has been done, although at too late a date for the annual report. The worst effect is to cause an appearance of large unexpended sums on hand, when, in fact, by the time Congress gets the reports, the balance on hand is generally very small.

FINANCIAL STATEMENT.

Available July 1, 1871, as per Treasury statement	$76,059 89
Allotted November 6 and December 5, 1871, for special local surveys	800 00
Received from sale of public property	1,375 00
Available for year 1871–'72	78,234 89
Expended during the year	77,659 70
Balance	575 19
Appropriated June 10, 1872	200,000 00
Available July 1, 1872	200,575 19

At the commencement of the fiscal year the following contracts were outstanding:

Number.	Miles from Pittsburgh.	Work.	Contractor.	Paid on contract to July 1, 1871.	Paid during year 1871–'72.	Due to complete contract.
1	3	Chartier's Creek dam	Charles Cable	$6,894 96	$8,044 38	
2	10	Dredging at Merriman's	B. L. Wood, jr		999 07	$3,953 15
3	85	Twin Island dam and dike	C. M. Cole		2,605 91	
4	168	Marietta Island dam	do	1,903 11	9,082 53	
5	483	Medoc dike	Thomas Slemmens		6,758 00	
6		Wrecking above the falls	C. M. Cole		4,754 75	
7		Wrecking below the falls	J. H. Porter		8,390 50	

The first two contracts were made in September, 1870, but the season was then so far advanced that I was obliged to give contractors until the end of 1871 for completing their work. The other contracts were made in April, 1871, the appropriation bill for 1871–'72 having been passed in March in good season for the summer's work.

CHARTIER'S CREEK DAM, THREE MILES BELOW PITTSBURGH.

This dam, as mentioned in my last annual report, is designed to close entirely the left one of the two channels into which the river is divided by Brunot's Island. Owing to the extraordinary long duration of low water last summer the contractor did not succeed in making such progress with this dam as I had hoped, and the necessity of leaving an opening in the dam until the last moment, in order not to stop the low-water commerce of Pittsburgh, was the cause of our needing more stone than had been calculated for. A flood coming just before the gap was closed washed out the opening to a great depth, and made its closure a matter of some difficulty. However, it was finally successfully accomplished and the dam was completed, though to a less height than originally

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intended. In order to protect it from ice and flood I had the upper side thoroughly graveled by dredge-boats. Last winter was an unusually bad one for ice, but this dam stood very well, being only slightly flattened out. Owing to its defective height it did not accomplish as much as had been hoped, and the interests that originally requested its construction became somewhat hostile to it. This spring while in Pittsburgh I had a meeting with the Coal Exchange and the Pilots' Association, and after a full discussion it was decided that no opposition should be made to the completion of the dam to the full height, so as to give the experiment a fair trial. On my part I agreed to remove the dam should the river interests continue opposed to it after it had been thoroughly tested. This can easily be done by the dredge-boat. Five thousand five hundred and forty-three cubic yards of stone have been placed in this dam.

The effect of the dam being to make the Glasshouse side the only channel, it early became obvious that something would have to be done to improve the right side, so as to make it available after the left was closed.

GLASS-HOUSE DIKE, TWO MILES BELOW PITTSBURGH.

The improvement of this channel required the partial removal of the Glass-house Bar, and also the construction of a low dike to control the current after it had passed the bar at the head of Brunot's Island, and to prevent boats from being drawn into the pocket just below the head bar, and to the left of the channel. As there was an immediate demand for the construction of this dike, and no time for advertising for proposals, you authorized me to purchase stone for it in open market. By this means the dike was almost completed, but owing to carelessness in construction during my absence, it became impossible to finish it before winter, but even in its present condition it has served a most excellent purpose. A new contract will be let for its completion, and I hope to be able to state in my next report that it is finished. Two thousand five hundred and eighty-three cubic yards of stone have been placed in this dike.

DREDGING AT MERRIMAN'S, TEN MILES BELOW PITTSBURGH.

The contract at this place has nearly been finished, but the original estimate for excavation was entirely insufficient. The work will be continued and completed by the United States dredge-boat Ohio during the coming season. This bar is an almost solid mass of large bowlders resting on rock in position. Many of them are larger than the capacity of the bucket, and have to be removed by other means, or by digging holes deep enough to bury them in. In many cases the dredge has lifted thin strata of the underlying rock without much trouble, but all the work on this bar is both tedious and difficult, and uses up dippers and dipper-handles. There is no doubt, however, but that the work can ultimately be accomplished. It is probable that a portion of the lower bar will also require removal. Should the dredging fail to give the necessary relief it will be supplemented by a dike, though there is reason to fear that the latter will cause an objectionable increase in velocity.

During the last coal-boat rise thirteen boats or barges were lost in this vicinity, mainly on account of the lack of judgment of a pilot in attempting to get a sinking coal-boat through this bad passage instead of landing it above.

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Under the contract with B. L. Wood, jr., 3,799 cubic yards of dredging have been removed up to the close of the fiscal year.

TWIN ISLAND DAM AND DIKE, EIGHTY-FIVE MILES BELOW PITTSBURGH.

The work previously done upon the dam at the head of the Upper Twin, and upon the dike at its foot, not having proved sufficient, a new contract was made in April, 1871, for completing the work. Under this contract 2,005 additional cubic yards of stone have been used, and the contract has been closed. It is believed that as soon as the new channel at the foot is finally formed there will be no further trouble here. This work could be greatly helped by scraping, and it is hoped that we will soon have a boat with scraper attached that will be available for such work both here and elsewhere.

MARIETTA ISLAND DAM, ONE HUNDRED AND SIXTY-EIGHT MILES BELOW PITTSBURGH.

This dam was entirely constructed last season, partly, however, in the previous fiscal year, and proved a great success while it remained in good condition. Three thousand one hundred and sixteen cubic yards of stone were placed in the dam during the fiscal year just closed, and 7,833 during the year preceding, the total amount in the dam being 10,949 cubic yards. Unfortunately, soon after its construction, and before it had a fair chance to consolidate, it had to undergo one of the worst seasons for ice that we have ever had. The result was satisfactory in as far as it showed that there need be no difficulty in making a dam stand in this locality and on this method of construction. It differs from the older dams on the river in being built straight across the channel to be closed, instead of being built in the upper prolongation of the island shore. The ice did not injure either shore end, but flattened down the middle. The dam will be repaired during the coming season. It will require 4,500 cubic yards to put it in good condition.

MEDOC DIKE, FOUR HUNDRED AND EIGHTY-THREE MILES BELOW PITTSBURGH.

The dike at this place was finished soon after the fiscal year began. During the year, 3,230 cubic yards of stone were placed in this dike, making a total of 9,520 cubic yards. This place has been much improved, but to thoroughly complete it a further extension of the dike will be necessary.

REMOVING SNAGS AND OBSTRUCTIONS.

Two fleets were employed for this purpose, one clearing the river between Pittsburgh and Louisville, and the other between Louisville and Cairo. Each fleet consisted of a steamboat, two crane-flats, and two common decked flats. They did a great deal of good, but from the lack of appliances worked by steam, and general lack of power, they were not as efficient as I had hoped. Too much time was consumed in getting rid of snags after they were raised. I am satisfied that a single snag-boat constructed on the model of those in use on the Mississippi, but made narrower (so as to pass through the canal) and of lighter draught, could keep the Ohio thoroughly clear without difficulty. I have estimated for the construction of such a boat.

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Besides the snag-fleets, I employed John Cool, of Pittsburgh, to work with four horses and a pair of large wheels, such as are used for moving boilers and heavy machinery, in removing some very bad rocks from Horsetail and Lowery's, two bars within seven miles of Pittsburgh. The work was done when there was only about 2 feet of water on these bars, and was very successful. Five hundred and twenty rocks, of all sizes, up to 4 tons in weight, were removed from Horsetail, and 531 from Lowery's. A very few large rocks are yet left, but efforts will be made to blast and remove them during the coming summer.

SURVEYS.

During the year careful surveys and maps, on the scale of 1 inch to 200 feet, with triangulated soundings, were made of the following places: Horsetail, White's, and the Trap, Beaver and Raccoon Shoals Line Island, Upper Twin Island, Charleston Bar, Augusta Bar, Snag, Bar, Medoc, Rising Sun, Gunpowder, Warsaw, Craig's Bar, and Grassy Flats, all being above Louisville. Below Louisville similar maps have been made of the harbor of Evansville, and of the dam at the head of Cumberland Island, known as the "Cumberland Dam," the former on a scale of 1 inch to 200 feet, and the latter of 1 inch to 500 feet.

The surveys made during the preceding season comprised Brunot's Island, Merriman, Deadman, Buffington, Eight-Mile Island, Guyandotte, Twelve Pole, and Four Mile. The present greatest lack of surveys is below the falls, where the "Major Sanders" could not get last season, on account of the closure of the canal; arrangements will be made to get a party below the falls during the low water of this season.

SURVEY AND INSPECTION STEAMBOAT.

The little survey and inspection steamboat, Major Sanders, belonging to this improvement, was unfortunately sunk in the fourth and last break-up of the ice of last winter. She was sold as a wreck, and we are thus without any independent means of conveyance. The Sanders was no great loss, as she was a singularly ill-contrived craft for our uses, having no facilities whatever for doing work aboard, and besides being low and unhealthy, she was so fragile that we always had to lay her up in corners, out of the way of larger boats, for fear they would crush her. The lack of stiffness, also, made it impossible to attach a scraper to her, which is a most desirable adjunct to an inspection and survey boat. It is expected that authority will soon be granted to build a suitable boat to take her place.

APPROPRIATION FOR YEAR 1872–'73.

On the 10th of June, 1872, Congress passed the appropriation bill for rivers and harbors, which contains an item of $200,000 for the Ohio. The two preceding appropriations were only $50,000 each, and but little could be done with them; but, with the increased appropriation, it is expected that great help will be given to a river-commerce that needs it very much. The record of contracts made under this appropriation belongs to the next annual report.

ESTIMATE FOR FISCAL YEAR 1873–'74.

The Ohio River contains 200 bars, a large majority of which need improvement. The rule, in applying whatever sums may be allotted to

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this river, is to spend them on the worst bars as far as the appropriation will go, the effect of which is that, after the worst bars are improved, the next worse come into notice, and are taken up in their turn. Besides building dams and dikes, and dredging, (about both of which operations there are friends and opponents,) obstructions must be removed, (on the utility of which all are agreed,) and engineering and office expenses must be met. To make detailed estimates of the cost of repairing or building a number of dikes is hardly necessary, as such estimates can best be made after the money is appropriated and just before operations are commenced. Bars are liable to change, and methods of construction are gradually improved by experience. We have now on hand detailed maps of all the bars above Louisville that will probably require attention for several years.

Our information below Louisville is not so complete, but it will be increased from time to time as required.

The Ohio is specially in need of a snag-boat, built like those in use on the Mississippi, but of lighter draught.

The Mississippi snag-boats have wooden hulls, and now draw 4½ feet, or about half a foot more than when they were launched. This is due partly to the strains they have undergone in their heavy work, but more to the fact that all wooden boats become water-logged, and every year draw more than the year before. With snag-boats this is a very serious matter, as they can only work advantageously during low water, and the less they draw the more useful they are. The only way to remedy this defect is to build the hulls of iron, which, though more costly at first, is by far the cheaper in the long run. Iron hulls are much stiffer than wooden ones, remain in good condition almost indefinitely, and draw no more water when ten years old than when first built. A snag-boat for the Ohio should not draw over 2 feet, and should not be more than 75 feet wide, so that she may pass through the canal. The cost of such a boat would probably be about $70,000, and she could keep the whole river clear from Pittsburgh to Cairo without any trouble. I know of no expenditure of funds that would give more general approval than the construction of such a boat.

I would, therefore, recommend an appropriation of $350,000 for use on the Ohio, with the understanding that as much of this sum as may be necessary shall be used for the construction of a light-draught snag-boat. I would also request that no part of this appropriation be expended for any local purpose, but that all of it be for the general improvement of the river. There are various towns that wish their harbors improved out of the general fund, when such improvements are of no use whatever to general commerce. I would recommend that no local work whatever be done, except where there is a special appropriation for the purpose. All the money that can be obtained for the Ohio is needed for purposes that will benefit its whole commerce. I think, however, that no work once begun should be given up until it is completed, whether its object be local or not.

LOCKS AND DAMS.

After long trial of other methods, the commercial interests of the upper end of the river have about concluded that, in that part of the river, the only radical method of improvement is the construction of locks and dams. The usefulness of these, however, depends entirely upon the practicability of making chutes from 200 to 300 feet wide, with gates and inclines so constructed that coal-fleets may be safely passed

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from one pool to another without being divided. By your appointment Major Weitzel and I were constituted a board to investigate and report upon this subject. We are not yet fully prepared to submit our report, but it will be completed before Congress meets.

We have already decided that the required conditions can be fulfilled by several plans, but we think before any effort is made to introduce this system on the Ohio it should be tested on the Monongahela. The president of the Monongahela Navigation Company is willing and anxious that the experiment should be made at Dam No. 1 of the Monongahela slack-water, and offers in behalf of his company to pay half the cost. I would strongly recommend that his offer be accepted, and that a suitable appropriation be made for this purpose. For further information I would refer to the report in question.

LIGHTS AND BUOYS.

I would again renew my recommendation that measures be taken to aid navigation on our western rivers by beacon-lights and buoys.

The bill now before Congress for the extension of the jurisdiction of the Light-House Board will secure all that is needed, and I hope that no objections will be made to its passage.

OHIO RIVER BRIDGES.

The only trouble with the bridges over the Ohio River during the past year has been at Parkersburgh, where the riprap around the channel-piers was carelessly put in, and some coal-barges were injured last winter by striking it. In accordance with your instructions, dated January 11, 1872, I visited this place, accompanied by Mr. Weston, and found the condition of affairs as stated. The Baltimore and Ohio Railroad Company, when my report (dated February 16, 1872) was forwarded to them, promptly promised to remove all obstruction from the channel. I have had no opportunity of inspecting the locality since, but as no further complaint has been made to this office, I infer that the company has performed its part satisfactorily. It is very important for the protection of navigation that the general bridge-bill, submitted by the Board of Engineers in Ex. Doc. No. 128, House of Representatives, third session Forty-first Congress, which is now before Congress, should pass, and thus prevent further trouble. The joint resolution which permits the construction of a low draw-bridge at Paducah should be repealed.

BRIDGING RIVERS UNDER STATE LAWS.

I think that the attention of Congress should be called to the propriety of passing a general law regulating the bridging of all navigable rivers. Under the present practice each State assumes entire control of all rivers that lie wholly within her boundaries, whether they are great navigable streams or not, and even assumes control of portions of the great navigable rivers when both shores are in the State. The result has been that under State laws the navigation of some large rivers, notably the Wisconsin and Wabash, has been ruined by improperly-built bridges. In other cases, as at Hastings and Saint Paul, on the Mississippi, the State has permitted the erection of bridges of less span than the United States laws require. This matter is a serious one on the Ohio, as the first forty miles of this river are wholly in the State of

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Pennsylvania, and it is not improbable that a bridge will soon be built below Pittsburgh that will not conform to United States laws, and may be a dangerous obstruction to navigation. The question is also important on the Monongahela, over which a bridge is now proposed by the Pennsylvania Central Railroad, to which there is much opposition by the river interest. Another source of trouble is that State laws provide for no supervision of a bridge while in course of erection, to see that even such laws as are passed are observed.

CAUSEWAY AT WHEELING ISLAND.

An effort was made during the last session of Congress to procure authority to close the right channel of the Ohio at Wheeling Island by a causeway, and the matter was referred to me for examination and report. My report is dated April 2, 1872, and was adverse to the granting of the privilege requested.

HARBOR OF EVANSVILLE, INDIANA.

The survey of this harbor was made, while I was absent in the South establishing water-gauges, by my principal assistant, Mr. William Weston, civil engineer. The report thereon has been printed as Ex. Doc. No. 42, Senate, second session Forty-second Congress.

CUMBERLAND DAM.

This is an old and unfinished dam across the Ohio, near the mouth of the Cumberland. It was surveyed by Mr. Weston, and his report is printed as Ex. Doc. No. 165, House of Representatives, second session Forty-second Congress.

MISCELLANEOUS WORK DURING THE YEAR.

Survey at head-waters of the Monongahela.—This survey was made as ordered. The report thereon has been printed as Ex. Doc. No. 144, House of Representatives, second session Forty-second Congress.

Survey of Licking River as a harbor of refuge.—This survey has been completed, and the report thereon has been published in Ex. Doc. No. 252, House of Representatives, second session Forty-second Congress.

River-wall at Newport Barracks.—The subject of the construction of a river-wall on the Licking side of the United States property at this place was referred to me for report. After a careful survey and borings I submitted a report on the 8th of June, 1872.

Mississippi River between Alton and mouth of the Meramec.—I was a member of the board of engineers, convened by special order No. 20, dated headquarters Corps of Engineers, February 7, 1872, for the consideration of the improvement of the Mississippi between Alton and the mouth of the Meramec. Our report thereon has been printed as Ex. Doc. No. 68, Senate, second session Forty-second Congress.

Water-gauges on the Mississippi and its tributaries.—These gauges, with an additional one at Natchez, have all been established, and the method of construction, with details about recent high and low waters, is fully set forth in my report dated February 19, 1872. All observers are supplied with record-books and blanks for weekly reports to this office. I had a great deal of difficulty at first in getting these reports properly made out, but I believe that all observers now understand what is required

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of them, and reports are promptly and regularly received from all stations, except that at the mouth of White River. I expect soon to send a special agent to this point to straighten out matters and secure regular reports.

From all that I can learn the system has given great satisfaction.

Respectfully submitted.

WILLIAM E. MERRILL,
Major Engineers.

General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

K 1.

EVANSVILLE HARBOR, INDIANA.

OFFICE OF OHIO RIVER IMPROVEMENT,
Cincinnati, Ohio, February 13, 1872.

GENERAL: I have the honor herewith to submit a report on the improvement of the harbor of Evansville, Indiana, made by my assistant, Mr. William Weston, civil engineer. At the time your instructions, of December 5, were received, I was absent in the South on duty connected with the construction of water-gauges on the Mississippi and its tributaries, and therefore assigned the work to him.

I have carefully gone over the whole subject with him, and the report fully meets my views in the matter. I should prefer being permitted to build a 9-foot dike on a hurdle foundation, as this method of construction seems the best for obviating one of our greatest difficulties, the settling of dikes after exposure to high water for one or two seasons. Some device of this kind is a necessity for dikes on the lower Ohio, where the bottom is unstable, and the plan indicated appears now to offer the best chances of success. The estimate for this, as given, is $89,850, and therefore I think that it would be best to have an appropriation of $90,000.

The intention of the work recommended is to throw the channel across the low neck which connects the bar with the shore-bar at the mouth of Big Bayou. It is quite possible that some dredging may be necessary to assist the river in taking this course. I would make no estimate for this, however, as it can be done more cheaply and satisfactorily by the Government dredge-boat than by private contract, and no special appropriation would be required.

Respectfully, your obedient servant,

WILLIAM E. MERRILL,
Major of Engineers.

General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

OFFICE OF OHIO RIVER IMPROVEMENT,
No. 4 Public Landing, Cincinnati, Ohio, February 13, 1872.

COLONEL: I have the honor to submit the following report on the survey of the harbor of Evansville, Indiana, made December 9, 1871. The accompanying map, drawn to a scale of $\frac{1}{2400}$, or 1 inch to 200 feet, shows the present condition of the river at this place from the mouth of Pigeon Creek to a point two miles above the city wharf, including the extent and height of the present harbor-bar and the approaches to the

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public landing. All hydrographic work has been reduced to the low water of the past season, which corresponds very closely to extreme low water. The soundings given were all located by triangulation, and extend up to where the bed of the river continues at a very uniform section for several miles. Below Pigeon Creek the deep water hugs the Indiana shore around the bend far beyond the city limits.

In addition to the general survey, observations were taken to show the direction and velocity of the current in the main channel of the river approaching the harbor-bar, and a line of levels run to determine the surface slope.

The results of the survey, as shown by the map, prove that the bar encroaching upon Evansville Harbor is a continuation of the shore-bar above, whose origin is to be referred to the fact that the width of the river-bed between banks is largely in excess of that required for low stages of water. The misfortune of the city landing seems to be that it is too far up stream, and that the main current and channel of the river strikes across to the Indiana shore at a point in the bend below the place set apart by the city to receive it. Behind the lower point of the bar there is at present an inlet or pocket of sufficient depth and width to allow boats to come up to the landing at low water, but the bar is closing in upon the shore above, and the probability is that it will soon be joined to the shore throughout its whole extent, and will thus shut off all access of boats to the city wharf at ordinary stages of the river. This is the apprehended danger to the harbor, while the map shows in detail its present condition.

The results of the investigations made to ascertain "what was the condition of the channel-way of the Ohio at the time when the approaches to Evansville were most favorable and the landing most easily effected," were not wholly satisfactory, from the lack of any accurate records, maps, sketches, or historical matter whatsoever, bearing upon the subject. The only information to be obtained on the point was from steamboat and river men, who had been familiar with this portion of the river since the early days of the city. My principal informant was Captain James W. Stinson, who has had a practical knowledge of the harbor for upward of forty years, and whose testimony is quite full and trustworthy, and is corroborated by the statements of others. He says that when the harbor was in its best condition the dry shore-bar of Green River Island terminated at the mouth of the Big Bayou, but that below this, and separated from it by shoal water, over which boats could not pass at the lowest stages of the river, there was a bar similar to the present harbor-bar, but smaller, with its lower end opposite the foot of Locust street. This is 1,500 feet above the lower end of the bar in its present condition. At low water, boats could then approach the present landing directly from any point below Locust street, but could not land above without rounding the foot of the bar and passing up behind it. This was thirty years ago or more. Subsequently this lower bar increased in extent, but was very changeable from year to year. After unusually high water it would come out much larger than before, and then, following successive seasons of comparatively low water, would again be reduced to its ordinary size. After the flood of 1867 the bar approached nearly to its present size, but it was subsequently greatly reduced. For the past few years its law of growth has seemed to undergo a change, and notwithstanding the existence of conditions of the river once favorable for its reduction, it has persisted in growing, and is now more formidable than ever before. The low neck connecting it with the shore-bar has filled up, and from this point down it is gradually attaching itself to the main shore. The cause of this growth is not easily determined. It is not yet perfectly certain that it is more than temporary, to be again reduced or counteracted under certain unknown conditions of the river. The experience of the past two years, however, makes this supposition improbable.

The wreck of the steamboat Missouri, which sunk a mile and a half above the city in 1867, may have led to an increase of the bar, though probably its influence was little, as it is out of the main channel, and, lying up and down the river, forms but a small obstruction.

Very little harm, I think, resulted from the wrecks sunk at the foot of the bar in November, 1870. They were very near its lower point, and perhaps caused some increase in the deposit of sand immediately below them, but nothing more. They were entirely removed during the past summer.

The bad state of the harbor is frequently attributed to the increased obstruction of the slough or "cut-off" behind Green River Island. Steamboats have passed through this slough at high water, but no one knows that any water has ever passed through it at low or ordinary stages of the river, and I think its influence in its best condition was small, and has been greatly overestimated. The origin of the change is to be looked for, I think, in a gradual and probably permanent change in the channel of the river, causing it to strike the Indiana shore at a lower point in the bend than formerly.

When the approach to the city wharf was most favorable, the high bank of the Kentucky point opposite extended out into the river some 200 feet further than at present, with a tendency to turn the channel, which comes down this shore, into the bend on the Indiana side, higher up than its present position. It will be seen by the map that

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the width of the river between banks is here from 200 to 400 feet in excess of what it is above, so that the conditions are favorable for an increase in the extent of the former bar. This result has, no doubt, been aggravated by the action, or inaction, of the city, in allowing material for grading their streets and wharf to be taken from the gravel point on the Kentucky side, directly opposite the troublesome bar. The reduction of this salient point, as far as it has been allowed, has had the same effect on the low-water channel that the corresponding loss in the high bank has had in diverting from the city wharf the force of the high-water channel.

Of the means of improvement that have been suggested but a few deserve notice. The city authorities last summer made a small and unsuccessful effort to cut a channel through the low point between the shore and river portions of the bar, in hopes to secure a draught of water sufficient to cut out a through channel to their landing from above. The difference of level between the surface of water in the main channel and in the bay at the time of the survey was only 0.4 feet, while the bar is here very wide and constantly increasing in height, so that, under the most favorable circumstances, nothing more than a temporary benefit is probable from any effort of improvement in this direction. Whether the re-opening of the "cut-off" would help the matter is very doubtful, and its probabilities need not be discussed, as the project is utterly impracticable.

I consider the only efficient means of improvement to be a dike or wing-dam thrown out from the Kentucky shore, above the city, to turn the current of the river against the bar and scour it out. Its material is light sand, which could not stand the current if once turned against it. Although such a dike properly constructed would, no doubt, accomplish this object, the question of its exact position, direction, and extent, to secure efficiency and economy of construction, is not easily determined. The surface slope of the river at the time of the survey was 0.37 feet per mile, with a maximum current-velocity of two and a half miles per hour. This is not enough to excite apprehensions of any troublesome eddies or cross-currents.

The dike or dam proposed contemplates turning the channel across the low neck between the harbor and shore portions of the bar. It starts out from the Kentucky shore, about a mile above the city wharf, and runs across and down the river till it strikes the present low-water shore-line of the bar, making a total length of 2,700 feet. To build this dike to a height of 9 feet above low-water level, with a top width of 12 feet on up-stream slope of one on one, and a down-stream slope of one on three, would require 46,200 cubic yards of riprap stone. Estimating the cost of quarrying and placing in dam at $1.75 per cubic yard, the total cost would be $80,850. After the dam has been exposed for a year or two to high water and ice, it will probably require an additional sum for repairs, but this need not be considered at present. When the channel has been once opened, a less height of dam may answer the purpose, and this expense for repair may thus be avoided. As the lower part of the dam will have a sand foundation, some repairing can scarcely be avoided. At an estimated cost of $6 per linear foot, hurdle-work, 100 feet wide, could be laid for a foundation where the dam was built on a sandy bottom. For the first 1,200 feet, the bottom is gravel; using hurdle-work for the remaining 1,500 feet, on sand, the cost would be increased $9,000, or to $89,850. Experience is wanting to determine the efficiency of hurdle-work to prevent scour in foundations on sand in the Ohio. Its advantage, however, would undoubtedly be sufficient to compensate for the extra cost.

Another method of construction would be to put brush in the center of the dam, up to low-water level, for a width of 30 feet, securing it by piles set 20 feet from each other, in two rows. If this method be followed, the estimate would be for—

36,200 cubic yards of riprap, at $1.75	$63,350
2,109 cords brush, at $3	6,327
240 piles, at $3	720
Making the total cost	70,397

To build the dam to a height of 6 feet above low water, but otherwise of the same dimensions as above, would require, if built of stone, 30,000 cubic yards, at a cost of $52,500. If with a center core of brush 20 feet wide, and as high as the low-water surface, the cost would be reduced to $45,774. It is of course impossible to foretell what the effects of the dike will be. Like all river-work of this character, it is only by awaiting actual results that the efficiency of any plan can be demonstrated. With the dike built as proposed, it may afterward be found necessary to extend it in order to accomplish all that is desired. The position of the dam was laid down with the idea that, if extension was found necessary, the work now proposed would be wholly available and adapted to subsequent additions. Under the circumstances, I think that the extent of the dike as indicated on the map, reaching as it does quite across the low-water channel, is all that should now be recommended. Nothing less than this is likely

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to give the desired relief. If anything more is found necessary, it can best be determined after the results of this work become known.

The estimates for the several plans suggested above stand as follows:

For a dam 9 feet above low water:	
of stone, with hurdle foundation	$89,850
of stone, without hurdle foundation	80,850
of stone and brush	70,397
For a dam 6 feet above low water:	
of stone, with hurdle foundation	61,500
of stone, without hurdle foundation	52,500
of stone and brush	45,774

A more obvious though indirect method of improvement would be to move the city landing down stream 2,000 feet; this would take it below the point of the bar and out of its present trouble. The water here is deep, the approaches good, and the bar not likely to get down stream far enough to again interfere. The objections to this are the cost of constructing a new wharf, its removal from proximity to the business portion of the city, and the obstruction of a railroad already located at this landing. The present city wharf cost $113,000. A similar wharf below the bar is estimated to cost from $200,000 to $250,000.

The following statistics of the trade, &c., of Evansville are taken from a report lately prepared by Mr. V. Sorenson on the commerce of the city. His report is quite complete in detail, but too long to be reproduced here. I give only a summary of its most important points.

The total amount of internal-revenue tax collected from all sources in the first district of Indiana for the year 1871 was $914,037.56; for the past three years, $2,190,064.81.

Value of imports at the port of Evansville for the year 1871, $169,588.30; duties collected on above, $69,771.87.

The number of steamboats inspected at the port of Evansville for the year ending June 30, 1871, was 36; amount of fees collected, $1,002.25.

Number of steamboat arrivals for 1871, 2,568; passed without landing, 154; tonnage of port, 9,936.44 tons; number of vessels, 68.

Total sales of merchandise for 1871, $22,732,365.80; total value of manufactures for 1871, $5,469,762.61.

The following are some of the most important articles of export for the year, and amount of each:

Corn, bushels	1,020,580	Oats, bushels	208,802
Cotton, bales	37,243	Pork, barrels	38,064
Dried fruit, pounds	269,100	Tobacco, hogsheads	32,197
Flour, barrels	237,099	Wheat, bushels	1,119,187
Goober pea-nuts, bushels	47,116	Whisky, barrels	25,397
Hay, bales	37,320		

Very respectfully, your obedient servant,

WM. WESTON,
Assistant.

Colonel WM. E. MERRILL,
United States Engineers, Cincinnati, Ohio.

K 2.

CUMBERLAND DAM.

OHIO RIVER IMPROVEMENT,
Cincinnati, Ohio, February 14, 1872.

GENERAL: I have the honor herewith to forward the report of Mr. William Weston, civil engineer, assistant on the improvement of the Ohio, on the "Cumberland Dam," a well-known work in the Ohio, near the mouth of the Cumberland. At the time your orders to survey this dam were given, I was absent in the South, engaged in the construction of water-gauges, and therefore assigned this duty to Mr. Weston. I

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fully agree with his recommendations, and think the repair of this dam a very necessary improvement.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

OFFICE OF OHIO RIVER IMPROVEMENT,
Cincinnati, Ohio, February 14, 1872.

COLONEL: I have the honor to submit the following report on the survey of the old dam in the Ohio River, near the mouth of the Cumberland, commonly called "the Cumberland Dam," made in accordance with your instructions, referring me to letters from the Chief of Engineers, dated October 21 and 26, and November 6, 1871. The object of the survey, as derived from these letters, was to show the present condition of the dam, to what extent it now fails in the object of its construction and operates unfavorably to the trade of the Ohio and Cumberland Rivers, and to furnish sufficient data for an estimate of the cost of its repair and improvement. Upon arriving at the dam, I found that the survey, to be in any way satisfactory, should extend from the head of the dam to the foot of the lower tow-head, a little more than three miles, and include both channels of the river, with a liberal number of soundings in each.

With the small sum allotted for the object, such a survey was quite beyond my means, and it was only by availing myself of the assistance voluntarily offered by the people of Smithland that I was enabled to make so extensive and complete a survey as the situation demanded.

The field-work was done between November 15 and 25, with the water at a very favorable stage, being at no time more than 2 feet above the lowest stage of the season. The soundings taken were all located, and on the map are reduced to the low-water surface of 1871. This was about 6 inches above extreme low water.

The accompanying map is drawn to the scale of 1 inch to 500 feet, and shows very fully the present condition of the river at the dam and through the channels on each side of Cumberland Island. An enlarged sketch shows the soundings on the dam. The total length of the dam is 2,600 feet. About one-fifth of this, being that portion in the main channel of the river near Dog Island, is covered from 3 to 5 feet at low water. There is no gap or breach through any portion of the dam, and the indications are that whatever subsidence has taken place, has been general, and without any displacement of the rock. The difference of level between the water-surface above and below the dam was half a foot at the time of this survey; at extreme low water it is greater, and in high water much less. The highest part of the dam is 400 feet from the eastern end, where it is 5.4 feet above low water. At this point very little, if any, change has taken place in height or condition since 1853, the date of the last work on it. West of this, toward the main channel, the dam gets gradually lower till it runs beneath the low-water surface at the west side of the "V." Its width on top from the "V" to Cumberland Island varies from 20 to 80 feet, and, with the gravel that is packed against it, it is, in some places, upward of 100 feet. From the "V" west, the general width on top is from 15 to 30 feet, with the side-slopes quite steep across the deep water.

The general condition of the river on each side of this island is shown by the map. From an examination of this, it will be seen that the dam, in its present condition, entirely fails in the object of its construction, whether that object was "to throw the low-water channel to the left of the island and by the town of Smithland, to avoid a shoal bar near the lower point of the island," as stated by Captain Richard Delafield, in report to the Chief of Engineers, dated January 16, 1833, or "to open an uninterrupted low-water communication with the Cumberland River, via the Kentucky Chute," as inferred from the report of Charles A. Fuller, United States agent and engineer, Ohio River improvement, to the Chief of Engineers, under date of September 1, 1854.

The bar opposite Hamletsburgh has been the controlling bar of the Lower Ohio for the past low-water season; boats that passed other bars without difficulty, almost invariably stuck here. During the time of the survey there was only a portion of one day when there was not one or more boats laboring to get over this bar. The only low-water steamboat-channel is now on the west side of the island, passing over the dam, and it is quite plain that the dam, as it is, is only an obstruction to this channel. Its effect is to give shoaler water on Hamletsburgh Bar, and to make a current at the dam

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so strong that many of the smaller tow-boats have to break their tows to stem it. At the head of the Kentucky Chute the wreck of the steamer Robert Moore, accompanied by a pile of snags, lies in what little channel there is, and at the foot of the island the chute at the left of the tow-head is very narrow and perilous, while the former main channel between the tow-head and island has little depth of water in it. In a word, the effect of the dam, in its present condition, is the anomalous one of not improving the Kentucky Chute, while it makes the main channel unnaturally bad. The necessity and importance of opening the Kentucky Chute to navigation at all stages of water, is generally acknowledged. When it is considered that the navigation of the Cumberland River must find an outlet through this channel of the Ohio, and that there is better water at times in the Cumberland than in this chute of the Ohio, no further argument is needed to show why attention should be given to keeping open this chute in preference to the other, although that is naturally the main channel. The same argument that existed for building the dam, now exists for this repair. A single incident will show how the case stands: In June, 1867, the steamboat Robert Moore, valued, with cargo, at $40,000, came down the Cumberland without difficulty, made an unsuccessful effort at each end of the chute behind Cumberland Island to get through, and upon a third attempt struck, and sunk in the upper chute, and proved a total loss. The loss by this accident was enough to rebuild the dam. No objection has been made by river-men or river interests to having the dam rebuilt, as there is plenty of width for navigation in the Kentucky channel. Two important questions for consideration are, whether the dam can be built up with a probability of its permanency and efficiency, without the need of constant repair; and, whether it will have the desired effect of opening a good and sufficient low-water channel past the mouth of the Cumberland, if so built. About the first point I think there can be no doubt, as the old dam is everywhere sound. Like all dams, it has settled a few feet, but without material injury. I cannot ascertain that the part now under low-water line was ever built above or up to it. The last work on it was done in 1853, and in the final report of Mr. Fuller, referred to above, he says:

"On the 24th September I was constrained to suspend the work for the want of adequate funds to complete it. * * * The work remaining to be done consists in finishing the portion between the 'V' and Dog Island, and in extending the dam along the dry bar to the head of Cumberland Island, a distance of about five hundred yards, which will require, in all, about fifteen thousand tons of stone."

This work was never done. The dilapidated condition of the dam, therefore, results mainly from the fact that it was never completed. The stone of the dam is everywhere cemented together by sand and gravel, and, for a foundation, is almost equal to solid rock. Building upon this, the work would be almost entirely free from such dangers and difficulties as attend the construction of any new dam of this magnitude. In answer to the question, whether the dam would have the desired effect to give uninterrupted navigation through the Kentucky Chute, if it were built up as proposed, the historical records of the present dam are to the point, and invaluable. Accompanying Captain Delafield's report of 1833 is a sketch of the locality, showing the line of the proposed dam, with the condition of the left channel when the work was commenced. This shows that the head of the Kentucky Chute was then dry at low water. The next record in this office is a sketch, indorsed by Lieutenant A. H. Bowman, Engineers, made in 1835, after the completion of the first work on the dam, showing good water through the chute.

The second work done on the dam was in 1843, and accompanying this report is a tracing of an official map, (marked A,) giving soundings in the Kentucky Chute before and after the work. This map shows that, subsequent to the first work, the chute at the head of the island had again become closed, and dry at low water, but that after putting into the dam but 55 per cent. of the stone required to build it up, as then proposed, (I quote from Mr. Fuller's report,) "the effect of this work, though but partially completed, has been already to open an uninterrupted low-water communication with the Cumberland River via the Kentucky Chute, at the head of the island, through which, at the date of the survey in 1848, no water whatever passed, but, on the contrary, a sand-bar, elevated some 2 or 3 feet above the low-water surface of the river, occupied the whole chute. During the present season of unusually low water, the channel on the Kentucky side of the island, through its entire length, is navigable for all boats that can approach it, either from above or below."

This state of things continued with but little change up to the high water of 1867, when a sand-bar formed at the head of the chute, greatly obstructing, but not entirely closing, the channel as before. If there could otherwise be any doubt about the efficiency of a completed dam, these facts make its success almost certain, for, with considerable water now passing through the chute, the circumstances are much more favorable than in 1833 or in 1853, when at the same stage the chute was dry. It must also be considered that, by opening the Kentucky channel, all boats will avoid the present serious obstruction at Hamletsburgh Bar, and there will then be no necessity for the improvements otherwise demanded there. The chute to the right of Dog Island

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is closed at low water by several reefs of rock crossing it, and no scour can take place, however high the dam is built.

The dam, I think, need not be built higher than six feet above low water, but should be extended 1,000 feet southerly, to reach the head of Cumberland Island. Its top width I have put at 20 feet, with an up-stream slope of one on one, and a down-stream slope of one on two. The amount of stone required to build the dam to these dimensions is 21,000 cubic yards.

Stone-quarries, accessible to boats at all stages of water, are found some six or eight miles up the Ohio, and, allowing $1.75 per cubic yard for quarrying and putting in the dam, the cost of the work will be $36,750.

As the stone is convenient, and can be boated at the lowest stage of water, and as there are few of the difficulties attending the work of repair that were met with in the original work of construction, I see no reason why the dam may not easily be completed in one season.

Very respectfully, your obedient servant,

WM. WESTON,
Assistant.

Colonel WM. E. MERRILL,
United States Engineers, Cincinnati, Ohio.

K 3.

SURVEY OF MONONGAHELA RIVER FROM NEW GENEVA, PENNSYLVANIA, TO MORGANTOWN, WEST VIRGINIA.

CINCINNATI, OHIO, *February* 5, 1872.

GENERAL: I have the honor herewith to submit my report on the survey of the Monongahela River from New Geneva, Pennsylvania, to Morgantown, West Virginia.

My absence in the South, on duty connected with the establishment of water-gauges, has hitherto prevented me from writing up the report, and since my return I have been somewhat delayed by the necessity of additional work on the maps, which I had expected to have found complete.

The act of Congress under which this report is made appropriates a sum of money for various surveys and examinations, and, among others, "for survey of the Monongahela River from New Geneva, in Pennsylvania, to Morgantown, in West Virginia." The act limits itself to the words quoted, and for instructions as to its intention you referred me to the chairman of the Senate Committee on Commerce, who directed me to apply to the Hon. J. C. McGrew, the Representative in Congress from the Morgantown district. Mr. McGrew gave me to understand that he had requested this survey at the instance of his constituents, who were practically deprived of water communication, except at rare intervals, and that they wished to have the Monongahela River so improved by locks and dams as to be always navigable to Morgantown. I have therefore made the survey with this view.

The Monongahela River proper is composed of the Tygart's Valley River and the West Fork, of which the former rises along the western slope of the Allegheny Mountains, and the latter in the hill country to the west of these mountains, both streams being wholly in the State of West Virginia. They run northward on lines nearly parallel, and unite at Fairmont to form the Monongahela, which at this point is crossed by the Baltimore and Ohio Railroad. The railroad, after crossing, follows a northwest course to Wheeling, where the river runs almost due north into Pennsylvania, preserving this general di-

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rection until it reaches Pittsburgh, where it unites with the Allegheny to form the Ohio.

The distances from Pittsburgh of the more important points on the Monongahela are as follows:

	From Pittsburgh.	From preceding place.
Pittsburgh	0	
McKeesport, mouth of Youghiogheny	15.7	15.7
Elizabeth	23.0	7.3
Monongahela City	32.0	9.0
Brownsville	57.0	25.0
Jacob's Creek, head of slackwater	84.1	27.1
New Geneva	85.6	1.5
Point Marion, mouth of Cheat	90.6	5.0
Pennsylvania and West Virginia State-line	92.3	1.7
Morgantown Suspension-Bridge	102.3	10.0
Fairmont	127.3	25.0

The principal tributaries of the Monongahela are the Youghiogheny, which heads in Maryland, near its western boundary-line, and is famous for the excellent coal on its banks, and the Cheat, a wild mountain torrent, running through deep gorges, and over numerous falls and rapids, that heads in the Allegheny Mountains, northwest of Staunton. The Youghiogheny is occasionally navigable in times of high water, but the Cheat is never so for a greater distance than two miles from its mouth. The lower part of the Monongahela, from Pittsburgh to Jacob's Creek, two miles below New Geneva, is made permanently navigable by means of locks and dams. To understand fully the condition of affairs, a brief history of this improvement must be given.

The Monongahela Navigation Company was chartered by the State of Pennsylvania, in March, 1836, for the purpose of making "a lock navigation on the river Monongahela." Their object was to make "a complete slackwater navigation between the points herein mentioned, to wit, the city of Pittsburgh and the Virginia State-line." It was provided that if the company did not commence within five years, and "complete the navigation to the Virginia State-line aforesaid in seven years thereafter," all their rights and privileges should revert to the State. These restrictions were changed from time to time, and the present condition of this work and its legal obligations as to extent are as follows:

Slackwater navigation has been extended by six dams, with corresponding locks, from Pittsburgh to Jacob's Creek, eighty-four miles from Pittsburgh, two miles below New Geneva, and eight and one-fourth miles below the Virginia State-line. The obligations of the Monongahela Navigation Company to extend their slackwater to the State-line have been modified by the act of April 8, 1857, which reads as follows:

That whenever the construction of sufficient locks and dams to extend the slackwater on the Monongahela River from the Pennsylvania State-line to Morgantown, in Monongalia County, Virginia, shall have been commenced, it shall be the duty of the Monongahela Navigation Company to commence the construction of lock and Dam No. 7 in such manner and on such plan as will extend the navigation from its present terminus to the Virginia State-line, and complete the same simultaneously with the completion of the work extending to Morgantown. That so much of all acts heretofore passed as have reference to the time of completion of said improvement to the Virginia State-line be, and the same are hereby, repealed.

On the present slackwater there are six dams, located as follows:

At Pittsburgh, Dam No. 1; lift 8 feet; 2 locks.

At Port Perry, Dam No. 2; lift 8 feet; 2 locks.

Just above Elizabeth, Dam No. 3; lift 8 feet; 1 lock.

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Near Belle Vernon, Dam No. 4; lift 10 feet; 1 lock.
Two miles above Brownsville, Dam No. 5; lift 14 feet; 1 lock.
At Rice's Landing, Dam No. 6; lift 14 feet; 1 lock.
The cost of these dams was as follows:

1842.—Dam No. 1, with one lock	$96,000
Dam No. 2, with one lock	96,000
Dam No. 3, with one lock	Not given.
Dam No. 4, with one lock	Not given.
1856.—Dam No. 5, with one lock Dam No. 6, with one lock	188,476

It should be stated that the additional locks at dams Nos. 1 and 2 were added after the original construction, and do not appear in this estimate of cost. The cost of the first two dams was, however, much increased by damages from floods during construction. It is estimated that but for these accidents these two dams would have cost $67,000 each. The cost of offices and toll-houses is not included in the expenditures reported. The cost reported for dams 5 and 6 includes all incidental expenses, the cost of clearing the channel at several places, and some extra work on Dam No. 4. It would probably be fair to put the cost of these dams at about $90,000 apiece.

The locks are 190 feet long by 50 feet wide, excepting the new locks at dams 1 and 2, which are 250 by 56. These last cost $56,800 and $50,000, respectively.

As this river is already slackwatered for eighty-four miles, with a proviso for the continuance of this method of improvement nine miles farther to the State-line, and as the inhabitants of the Upper Monongahela are unanimous in their wish that any further improvement of the river should be on the same system that has been so successful for the lower portion, I have limited myself to the consideration of improvement by locks and dams. Moreover, the fall of the river between Morgantown and the head of the present slackwater is so great—28 feet in eighteen miles—and the supply of water is so small in summer, that no other method would give the required relief.

The survey from Morgantown to New Geneva was made in August, 1871, during low water, by Messrs. Charles Reichspfarr, E. A. Chase, and J. F. Wilson, civil engineers. As the slope of the river was the most important point in a slackwater system, special attention was paid to the level-lines, which were run twice each day, and afterward verified by a continuous leveling both ways, so that each portion of the line was gone over four times. The following table exhibits the height above slackwater at Jacob's Creek of the low-water river-surface at some of the more prominent points on the river. On the maps this is given for every station, but the full table is too lengthy for insertion in the text of the report:

	Distance in miles.			Height in feet above slackwater.	Fall in feet from preceding station.
	From Pittsburgh.	From Jacob's Creek.	From preceding station.		
Coburn's Creek	103.72	19.62	0.00	29.35	.....
Decker's Creek	102.40	18.30	1.32	28.56	0.79
Morgantown Suspension Bridge	102.25	18.15	0.15	27.97	0.59
Morgantown Ripple, above	101.49	17.39	0.76	27.43	0.54
Morgantown Ripple, below	101.36	17.26	0.13	25.26	2.17

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	Distance in miles.			Height in feet above slackwater.	Fall in feet from preceding station.
	From Pittsburgh.	From Jacob's Creek.	From preceding station.		
Granville Island, head	100.51	16.41	0.85	24.82	0.44
Dent's Run	100.29	16.19	0.22	24.81	0.01
Granville	100.20	16.10	0.09	23.55	1.26
Hamilton, or Jimtown	99.00	14.88	1.22	23.12	0.43
Jimtown Ripple, above	98.91	14.81	0.07	23.08	0.04
Jimtown Ripple, below	98.55	14.45	0.36	20.53	2.45
Courtney's Run	98.29	14.19	0.26	20.52	0.01
Collins's Upper Ripple, above	97.28	13.17	1.02	20.33	0.19
Collins's Upper Ripple, below	97.27	13.08	0.09	18.21	2.12
Collins's Lower Ripple, above	97.05	12.95	0.13	17.97	0.24
Collins's Lower Ripple, below	96.92	12.82	0.13	15.85	2.12
Howitt's Ferry	96.22	12.12	0.70	15.56	0.29
Three Sisters	93.63	9.53	2.59	15.23	0.33
Crooked Run Ripple, above	92.51	8.41	1.12	14.99	0.24
Crooked Run Ripple, below	92.40	8.30	0.11	13.21	1.78
Pennsylvania and West Virginia State line	92.30	8.17	0.13	13.20	0.01
Saddler's Bar	91.79	7.69	0.48	12.99	0.21
Point Marion, mouth of Cheat River	90.60	6.48	1.21	12.86	0.13
Cheat River Ripple, above	90.48	6.38	0.10	12.82	0.04
Cheat River Ripple, below	89.47	5.37	1.01	7.03	5.79
Crow's Ferry	89.14	5.04	0.33	6.87	0.16
Dunkard Creek Ripple, above	88.11	4.01	1.03	6.43	0.44
Dunkard Creek Ripple, below	87.51	3.41	0.60	1.79	4.64
Friendship Hill	86.62	2.52	0.89	1.61	0.18
New Geneva Ripple, above	85.87	1.77	0.75	1.56	0.05
New Geneva Ripple, below	85.63	1.53	0.24	0.37	1.19
Glasshouse	84.48	0.38	1.15	0.08	0.29
Jacob's Creek	84.10	0.00	0.38	0.00	0.08

The original intention of the Monongahela Navigation Company was to have 4 feet of water on the lower miter-sills of their locks when the river was "dead low." They have found by experience that this is not enough to secure such navigation as is demanded by the boats that use the improvement, and they have since adopted the rule of giving 6 feet. In the old work this is secured by dredging and by raising the dams whenever it becomes necessary to repair them. Guided by this experience, I have adopted 6 feet as the minimum depth of water in the extension of the slackwater to Morgantown.

The first consideration to be noted is the obligation of the navigation company to extend their slackwater. By examining the preceding table it will be seen that the height to be overcome by such extension, so that the slackwater may stop exactly at the State-line, is 13.20 feet. But it is manifest from the wording of the acts of the Pennsylvania legislature that they intended to compel the company to extend their work so that it would connect as completely with any work on the Virginia side of the line as if the two works formed parts of one whole. As no Virginia company could build a dam in Pennsylvania, and as their dam would be useless if there were not sufficient water below to enable boats to get to it, it follows that the obligation of the navigation company should be interpreted as requiring them to secure 6 feet of water at the State-line and up to it. An examination of the profile shows that, to get 6 feet on Saddler's Bar, half a mile below the State-line, an elevation of 18.75 feet is required above the present terminus of slackwater. By dredging a channel 1,150 feet long and 200 feet wide through this bar, which would require the removal of 8,000 cubic yards, the necessary lift to be overcome might be reduced to 17 feet; but no further dredging of this bar would be of any service, as the shoalness of the river below the mouth

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of Cheat would necessitate so much additional dredging there that it would be more economical to gain the necessary depth by dams. As lifts of either 18¾ feet or of 17 feet would make two dams necessary, and as two dams of 9½ feet would cost but little more than two of 8½, the estimate will be based on the former supposition, and dredging will not be considered. The second method would probably be more expensive than the first, as the cheapest dredging on the Ohio costs 90 cents per cubic yard, though it is possible that in slackwater a contract might be taken for less.

The pecuniary value of the obligation of the navigation company may therefore be estimated at the cost of constructing two additional locks and dams with a total lift of 18.75 feet. The cost of a lock and dam with a lift of 9½ feet, built like those already constructed by this company, I should estimate at $80,000. The total cost of construction would therefore be $160,000, and this is the sum at which the pecuniary obligation of the Monongahela Navigation Company should be estimated.

Assuming, in the next place, that it will be the desire of the navigation company, as it certainly is their interest, to spend this amount of money to the greatest advantage, and that they will not object to having dams built in Pennsylvania with slackwater extending into West Virginia, provided that they themselves are not compelled to spend any more than they are now bound to in order to carry out existing obligations, I will proceed to discuss the question of the extension of the slackwater to Morgantown purely as a matter of engineering.

Having ascertained the best method of accomplishing the work, and its cost, I will subtract from the latter the present value of the obligation of the navigation company as determined above, and the remainder will show the sum to be furnished by others, and therefore the net cost of the extension to Morgantown.

The first question to be settled is the limit of lock-lift. This, the experience already acquired on this river shows, should not much exceed 10 feet. It is true that locks 5 and 6 have a lift of 14 feet each, but their management is difficult. They were expensive to build, and cost much in repairs, and the great pressure of water makes it unusually difficult to keep them in working order.

The rise to Morgantown is 28 feet, but this must be increased by at least 3½ feet, in order to give navigable water at Morgantown. We therefore have a rise to be overcome of 31.50 feet, which can easily be met by three dams of 10.50 feet each. Applying these levels to the profile we find that they suit the case admirably, and that there is no difficulty in getting 6 feet on the lower miter-sill of each lock, and that in no case is there any bar below a lock with less than 6 feet of water on it.

The first dam, or Dam No. 7, would be at the most convenient locality below Jacob's Creek; No. 8 would be about one-fourth of a mile above Crow's Ferry; and No. 9 at the dam at Collins's Ripple. Dam No. 8 would have the additional advantage of making slackwater up the Cheat River for a distance of over two miles. It is well known that there are valuable iron deposits up this river that have hitherto lacked development on account of the inaccessibility to a market, and a partial slackwatering of this stream may stimulate others to complete the work by additional dams, or by a tramway. All of the localities selected may be varied slightly after special examinations have been made, but it is believed that no great change will be found necessary. The time and funds at my command did not enable me to send back parties to make special surveys and borings for detailed estimates, and until the survey

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was completed and mapped there was no information at hand which could indicate the places where special examinations were needed. It is thought, however, that the information acquired is sufficient to enable Congress to determine upon the propriety of making this improvement, and that the estimates submitted will vary but little from the fact.

The extension of the existing slackwater will be greatly to the advantage of the Monongahela Navigation Company, as whatever comes through the upper locks will be almost certain to continue to Pittsburgh, thus passing through the company's locks and paying their tolls. The great stimulus that would be given to all kinds of business in the valley of the Upper Monongahela would add largely to the revenues of the navigation company.

The most satisfactory plan for equitably adjusting matters between the old and new works would probably be to permit the navigation company to build Dams Nos. 7 and 8 according to the prescribed heights, and then re-imburse them for whatever amount they have expended in excess of their estimated obligation.

I should therefore estimate the cost of the extension of the existing slackwater to Morgantown as follows:

Three locks and dams, 10½ feet lift, at $90,000	$270,000
Deduct obligation of Monongahela Navigation Company	160,000
Net cost of extension	110,000

Whenever this work is actually undertaken, special surveys and borings should be made at each selected site, and the foregoing estimates should be thoroughly revised, as they are now only approximations.

It must not be forgotten that arrangements must be made to charge such tolls as will defray current expenses and will provide a reserve-fund with which to make both ordinary and extraordinary repairs.

There is no doubt that this improvement would be of great benefit to Morgantown and the country in its vicinity. At present all goods must be hauled over inferior roads from Uniontown, twenty-five miles, or Fairmont, twenty miles, or New Geneva, sixteen miles. From the latter point merchandise is often hauled up in flat-boats by horses—a very tedious and insufficient method of transportation.

Last year a very light boat, the West Virginia, drawing 12 inches unloaded, was built for the express purpose of running to Morgantown, in the hope that she might be able to run there regularly. She only succeeded, however, in making five trips in the year. Five trips were also made by other boats, so that ten steamboats in all have succeeded in getting to Morgantown during 1871. Some years since, four steamboats, the Globe, Eclipse, Lindsey, and Thomas P. Ray, succeeded in getting up to Fairmont. I can get no information about the details of these trips, but they must have been made during some unusual period of high water, as, to the best of my knowledge, no boats have been to Fairmont since.

In 1860 a company was chartered by the State of Virginia, with a capital of $200,000, for the purpose of slackwatering the Monongahela from the State-line to Clarksburgh, but nothing beyond a reconnaissance of the route was made, as the outbreak of the civil war stopped all such enterprises. Their charter has expired by limitation.

I requested Mr. George M. Hagans, of Morgantown, who has been actively engaged in endeavoring to secure the extension of the Monongahela slackwater, to give me a statement of the material interests in

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the section of the country proposed to be benefited by this improvement. He has done so in the accompanying paper, which I desire to attach as a part of this report. To him, to the Hon. J. K. Moorhead, president of the Monongahela Navigation Company, and to Mr. B. L. Wood, jr., of Pittsburgh, I am indebted for valuable assistance in preparing this report.

The annual report of the Monongahela Navigation Company for 1870 gives some statistics of their business that may be useful in this connection.

During the year 57,596,400 bushels of coal passed out of the Monongahela into the Ohio, and 132,917 passengers traveled on the slack-water. The gross receipts of the company were $232,498, of which more than 50 per cent. came from coal, coke, and slack. Forty thousand dollars were expended for repairs and dredging. Fifteen sheets of maps accompany this report.

Respectfully submitted.

WM. E. MERRILL,
Major Engineers.

General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

Statement of the mineral resources of the Upper Valley of the Monongahela River.

DECEMBER 1, 1871.

SIR: It is not proposed in furnishing data to enter into detail, but merely to state leading facts regarding the various and important interests to be enhanced by the extension of the improvement of the Monongahela River to Morgantown, West Virginia; which facts clearly demonstrate the advantages to be derived therefrom to be not merely local, but will include the Mississippi Valley in its entire length, premising that whatever conduces to providing such a considerable portion of our population with cheap fuel and other various articles of special and general necessity becomes a subject very properly of national importance.

It is universally conceded that, by the extension of this improvement up the right arm of the Upper Ohio, a region of immensely valuable resources would be reached, the surface of which is generally and peculiarly adapted to the various branches of agriculture, abounding in forests of the most valuable varieties of timber, and in mineral resources not equaled by any section of the same extent on the continent.

That portion of country more immediately benefited by the contemplated improvement would embrace several counties in Pennsylvania immediately adjacent and north of the State-line, and the counties of Monongalia, Marion, Taylor, and Harrison, in West Virginia, comprising a distance of about one hundred and forty miles, and including the best sections of the latter State.

In order to furnish information that may be regarded as entirely reliable, and acquired without any motive of self-interest or for deception, I beg leave to embody the following extracts from the geological report of Professor Rogers, State geologist to Virginia, and Dr. J. J. Stevenson, professor of geology and chemistry in West Virginia University.

Professor Rogers says:

"COAL.—Mean seam of the upper group, considered in regard to its thickness and the quality of the coal, as well as the extended area over which it is found and the facility with which it can be mined, is unquestionably the most valuable seam in the coal-measures, either in Virginia or Pennsylvania. By careful tracings conducted in both States this seam is extensively exposed in the Monongahela Valley, from a point some distance above Clarksburgh, Harrison County, to the State-line, near New Geneva, Pennsylvania, has been shown to be identical with that which is so largely developed in the northern part of the same valley in its prolongation in Pennsylvania, and which is disclosed so extensively in the vicinity of Pittsburgh. The following brief summary of the more important contents of the upper coal-group, as disclosed along our section, will serve to show the great affluence of this portion of the coal-measures as regards those valuable materials, coal and limestone, along the valley of the Monongahela:

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"COAL IN THE UPPER GROUP.

	Feet.
"First, or main seam, No. 1	9.00
"Second, or main seam, No. 4	3.06
"Third, or main seam, No. 11	5.06
"Fourth, or main seam, No. 24	7.00
"Making a total thickness of workable coal in this group along the line of our section of	25.00

"Aggregate veins of limestone in upper coal-group along the line of section of 50.10. Adding to these the 5 feet of coal and 24 feet of limestone in the lower shale and sandstone group, and the 9 feet of coal and 3 feet of limestone of the lower coal-group, we have for the whole extent of coal-measures embraced in our section a thickness of about 40 feet of coal and 70 feet of limestone—a result which, making all allowances for fluctuations in particular strata, is well calculated to show, in a striking point, the ample natural resources of this highly-favored portion of our State."

Dr. Stevenson says, in his official report of 1869:

"COAL.—The section just given shows a thickness in workable veins of 43 feet, all contained in a distance of barely fifteen miles, the seams having a regular dip; and there are few farms east of the Monongahela River from which coal may not be obtained at moderate cost. The upper coals are of such magnitude and of such easy access that they have all been worked to a greater or less extent.

"There are several points farther up the river on the west side where the Pittsburgh, Redstone, and Sewickly are all visible, the one directly over the other. At all of these points the several seams can be opened so as to drain themselves. The coal could be delivered directly into cars and conveyed on a tramway to the river. There can be no doubt that, were there an accessible market, the coal-mines of Monongalia County would assume as important a position as those of the neighboring counties of Pennsylvania, where the same seams are worked.

"IRON-ORE is plentifully distributed throughout the lower coal-measures, and valuable beds underlie the conglomerate. The ore-beds beneath the conglomerate are practically inexhaustible, and the deposits underlying the Pittsburgh coal have been worked to great profit at several furnaces in Pennsylvania, while in the lower coal-measures, as exposed on Decker's Creek, there are several beds of various degrees of purity which have proved available.

"LIMESTONE along the whole line of section is abundant, some strata of which yield a good hydraulic white lime, the lower carboniferous limestone containing some layers which burn into pure lime. The shales connected with the limestone series of the upper coal-measure are frequently so calcareous as to be true marls.

"SALT.—In nearly every instance where the conglomerate has been bored brine has been obtained. Such borings have been made on Cheat River, on Decker's Creek, on Scott's Run, and on the Monongahela."

This coal-field embraces at least one thousand six hundred square miles, one-fourth of which area is doubtless underlaid with mineral deposits, as described in the foregoing reports of the eminent gentlemen.

An estimate of the quantity, in tons, which, reduced to its pecuniary value, if means of transportation were provided, would show the following, predicating the thickness of the various seams at but 16 feet, where, by the reports above referred to, they measure 40 to 43 feet workable coal: Four hundred square miles contained 256,000 acres; each acre will yield 25,000 tons, aggregating 6,400,000,000 tons, which, estimated at 30 cents per ton, would amount to $1,920,000,000 for the coal alone; and it would be safe to estimate the iron mineral at an equal amount, aggregating the amount that would be added to the national wealth, if provided with facility for transportation, in the sum of $3,840,000,000.

In the development of this vast sum of wealth, there would be created a demand for subsistence and labor that would exceed five-fold in amount even this result. I am aware that to add to this brief sketch of the mineral extent and value of this valley would, perhaps, not be desirable or necessary. I will only say further that the annual agricultural product, including live stock, in these counties lying along the Monongahela River, in West Virginia, may be safely estimated at $5,000,000.

Respectfully,

GEO. M. HAGANS.

Colonel W. E. MERRILL,
Chief Engineer Ohio River Improvement, Cincinnati.

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K 4.

MOUTH OF LICKING RIVER, KENTUCKY.

CINCINNATI, OHIO, *March* 21, 1872.

GENERAL: I have the honor to submit the following report on the survey of the mouth of the Licking River:

The act of Congress approved March 3, 1871, making appropriations for various river and harbor works, contains a clause in its third section ordering a survey "at the mouth of Licking River, Kentucky, for harbor of refuge." For detailed information as to the special object of this survey, and the kind of harbor proposed by those at whose instance it was ordered, I was referred by the chairman of the Senate Committee on Commerce to the Hon. T. L. Jones, the late Representative in Congress from the sixth district of Kentucky. On consulting with Mr. Jones, I found that no definite plan had been proposed, and therefore I have been compelled to discuss the question independently of any suggestion from others.

The phraseology "harbor of refuge" is peculiar as applied to a river. On the lakes, a harbor of refuge is a natural or artificial harbor, generally without commerce, to which vessels run for safety in storms. But storms need not be feared on a narrow river, and river harbors of refuge must therefore provide a shelter from some other destructive force. A mere flood, however high, is not dangerous to river-craft, and the only danger that I know of against which boats on the Ohio ever seek protection is ice. When the Ohio breaks up after an ice-blockade, there is almost always a serious loss of property afloat, and security from this would undoubtedly be a great boon.

The winter just passed has been a particularly disastrous one in this vicinity, four steamboats and a large number of barges having been sunk or carried away. It remains, therefore, to examine the facilities afforded by the mouth of the Licking River for furnishing protection from ice.

The present survey of the Licking River, being by the act of Congress confined to an examination of its mouth, was only extended as far up as the first ripple, near the head of which is placed the railroad-bridge of the extension of the Louisville and Cincinnati Short Line, to connect with the Newport and Cincinnati bridge over the Ohio. The distance from the mouth to the foot of the ripple is 2.8 miles, and this is the extent to which the Licking is navigable in low water. I succeeded, however, through the kindness of the Hon. T. Wrightson, of the Kentucky legislature, in obtaining copies (unfortunately not entirely complete) of the surveys made of this river in 1829 by Lieutenants Turnbull and Grayson, together with the reports of Sylvester Welch, chief engineer of Kentucky, dated September 13, 1836, and of N. B. Buford, resident engineer Licking Navigation Company, dated November 1, 1837.

These maps and reports furnish all that is necessary to a full understanding of the characteristics of this river. The Licking River lies wholly in the State of Kentucky, and rises in the southeast corner of the State, its head-waters being within about twenty miles of the Cumberland Mountains, the boundary between Kentucky and West Virginia; its length is about three hundred and fifty miles, and it has been surveyed for a distance of two hundred and thirty-one miles, as far as the town of West Liberty. The Lower Blue Licks, ninety-eight miles from its mouth, is the highest point to which averaged-sized steamboats can

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ascend, even with lock and dam navigation, as the river above this point is very narrow and tortuous. The tributaries of the Licking are all small, excepting the south branch, which rises in the Blue Grass country near Winchester and Mount Sterling, and joins the main river at Falmouth, fifty-one miles from the Ohio. In the autumn of 1862, I crossed this stream at its mouth without wetting my feet, but that season was remarkable for its dryness. The slope of the river-surface from its mouth to Falmouth, fifty-one miles, averages 19 inches to the mile; thence to the Lower Blue Licks, forty-seven miles, 16⅛ inches to the mile; thence to the mouth of Slate Creek, forty-seven miles, 14⅛ inches to the mile; thence to West Liberty, eighty-six miles, 15 inches to the mile.

From these figures we see that if this river were ever slack-watered, assuming 10 feet lift of dams, which is as great as ought to be allowed, it would take 8 dams to reach Falmouth, 14 to reach Lower Blue Ticks, 20 to reach the mouth of Slate Creek, and 31 to reach West Liberty. The State of Kentucky once undertook to improve the navigation of this river by locks and dams, and built several locks; but work was stopped before any of the dams were finished, and the materials of the locks that were built were afterward sold, and the locks destroyed.

If the Licking were a river whose own store of ice could be neglected, the only question that could come up in connection with the use of its mouth as a harbor of refuge would be that of capacity; but while its ice seldom gives trouble, as during the winter just passed, it yet cannot be neglected, as in 1856 it was the cause of the most serious loss ever sustained from ice at this port. The following description of this disaster is taken from the Cincinnati Commercial of February 25, 1856: "All was quiet until about 9 a. m. yesterday, when the ice in Licking commenced moving, gorging some four or five feet high at the mouth." It crossed the Ohio "in huge fragments, and, quartering toward Main street, cut down several boats in a few minutes." The result was the destruction of eight steamboats and a large number of barges; the total loss being estimated at $100,000. Nothing as bad as this has occurred since, but it serves to show that the mouth of the Licking could not be relied upon as a certainly safe harbor while in its present condition.

The most natural method of providing shelter against ice and drift is manifestly to excavate a capacious basin in one of the river banks, out of the line of the current. This is the method which will first be examined.

Lateral basin.—In order to be generally available for all classes of steamboats, the excavated basin would have to be below the Newport and Covington suspension-bridge, which is 83½ feet above low water, and 21 feet above high water. Steamboats that have the means of lowering their chimneys, and whose pilot-houses are not more than 48 feet above the water surface, can get under this bridge whenever there is less than 35 feet of water in the river, but they cannot do so in higher stages; and boats plying between Cincinnati and southern ports, which do not lower their chimneys, cannot pass under it at all in ordinary stages of water. For these reasons, and in view of the great cost of excavating any basin in such high banks, a cost which would not be justified for the protection of only a portion of the commerce of this port, I have not thought it worth while to make any estimates for a work of this kind above the bridge. An examination of the portion of the river below the bridge shows that the only possible place for a basin is on the Newport side, as on the Covington side the banks are rocky, and average 30 feet higher than the Newport banks, being about 80 feet

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above low water. The suspension-bridge enters Newport midway between Madison and Bellevue streets, and, assuming that both of these avenues are needed for the service of the bridge, we evidently must take Bellevue street as our southern line.

The United States barracks extend as far southwardly as Taylor street, and this, therefore, must be our northern line.

We are therefore restricted in width of basin to the 450 feet between these two streets. In length, the basin could extend either to Isabella street, in which case it would contain 9½ acres, or to Cabot street, with a surface of 14 acres: but these spaces are not all available for vessels, as the retaining-walls and slopes will necessarily occupy a portion. The true measure of the capacity of these basins is their surface at low water, which will be given after the details of construction have been settled. To obtain 6 feet at low water would necessitate an excavation of 58 feet in average depth.

The number of cubic yards to be removed cannot be ascertained until the method of protecting the sides of the excavation is determined, as the prism of excavation is very different for protection by walls from what it is if earthen slopes are used. We will therefore pass at once to the consideration of the sides of the basins. They may be protected by retaining-walls, which would preserve the greatest practicable amount of interior space, but would be very costly, or by letting the earthen banks stand at their steepest natural slope, and protecting them from the weather by a paving of stone.

I have carefully calculated the required sizes of retaining-walls, and find that one 5.6 feet wide on top and 14 feet wide at bottom, with vertical back, would best meet the required conditions. Such a wall would have a cross-section of 568.4 square feet; and, for the smaller basin, its entire contents would be 37,893 cubic yards, which, at $9 per cubic yard, would cost $341,040. The wall for the larger basin would contain 56,840 cubic yards, and would cost $511,560.

Having ascertained the proper dimensions for the retaining-walls, we now know how much excavation in excess of that for the basin alone will be needed to make room for them. The total excavation for the smaller basin will be 754,000 cubic yards, at an estimated cost of $301,600, and for the larger, 1,241,200 cubic yards, at a cost of $496,480.

The expense of a retaining-wall is so great that the next question to be investigated is the possibility of dispensing with it, and using instead the natural slope of the bank, with a protection of paving against wash. This method, however, would considerably reduce the capacity of the basins, as the bounding streets must be preserved, and therefore the bases of the slopes will be taken from inside. Assuming that the greatest practicable slope in the soil in question will have an angle with the horizon of 50 degrees, we will then find for the sides of the smaller basin a surface of 124,704 square feet, which, at $5 per 100 square feet, will cost $6,235 for paving. A similar protection for the side-slopes of the larger basin, which have a surface of 185,004 square feet, would cost $9,250. But this last method would greatly reduce the amount of excavation to be made in either basin: for the smaller there would be a reduction from 754,000 cubic yards to 588,260, which would result in a saving of $66,296; for the larger the reduction would be from 1,241,200 cubic yards to 987,173, and the saving would be $101,611.

It should be remarked that all of the above estimates have been made on the supposition that the entire excavation is in alluvial soil. Should rock be met, which can easily be ascertained by boring, these estimates must be increased. The construction of these basins to a depth of 6

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feet below low water will necessitate a coffer-dam and steam-pumps. After the interior work is finished, the coffer-dam will have to be removed, with the earth on which it stood, and that outside of it, as far as the middle of the channel; this can only be done by a steam-dredge. These expenses I have estimated at $20,000.

The next question before us is to ascertain the capacities for sheltering vessels of the four different basins under consideration. Assuming the average steamboat as 250 feet long and 70 feet wide, and a coal-barge as 130 feet long and 24 feet wide, we see that the smaller basin, with retaining-walls, will give an available surface at low water of 6.7 acres, which will afford shelter for 16 steamboats or 93 barges; but with natural side-slopes, it will give an area of but 5.8 acres, which will accommodate 14 steamboats or 80 barges.

The larger basin will contain, with retaining-walls, 11 acres, which will suffice for 28 steamboats or 156 barges; with sloping sides it will contain but 9.8 acres, and will shelter 24 steamboats or 137 barges.

The cost of the land for the smaller basin at present prices would be about $90,000; for the larger basin it would be about $150,000.

Putting our preceding conclusions into tabular form, we have the following:

	Available surface in acres.	Accommodations. For steamboats only.	Accommodations. For barges only.	Cost of coffer-dam and pumping.	Cost of excavation.	Cost of retaining-walls.	Cost of revetting slopes.	Contingencies and engineering, 5 per cent.	Cost of land.	Gross cost.
Small basin	6.7	16	93	$20,000	$301,600	$341,040	.....	$33,132	$90,000	$752,640
Do	5.8	14	80	20,000	235,304	.....	$6,235	13,077	90,000	351,539
Large basin	11.2	27	156	20,000	496,480	511,560	.....	51,402	150,000	1,178,040
Do	9.8	24	137	20,000	394,869	.....	9,250	21,206	150,000	574,119

By this comparison we see that the cheapest basin or dock that could be made would cost $351,539; would contain an available surface of 5.8 acres; and would shelter 14 steamboats or 80 barges. It should also be borne in mind that an annual expenditure will be necessary to keep up this basin, as when either the Ohio or the Licking is high their waters come down heavily charged with sediment, which is rapidly deposited in eddies or in stagnant water. There would therefore be a constant annual expense for dredging this basin, or else it would soon fill up.

Besides all this, it is essential to the utility of the proposed basin, or to any project for utilizing the lower portion of this river, that the bar at its mouth should be removed. Estimates for this work are given further on.

I had thought that the river itself might be made available for the purpose suggested, and with that view I intended making estimates on two different plans, each based on the supposition that if the Licking ice were broken up before it reached the lower section there would be no danger from it. One plan proposed additional piers in the river above the railroad-bridge, so situated as not to interfere with the flow of water, but so that they would break up all large masses of ice. The other plan was to estimate for two dams, with an aggregate rise of 20 feet. These dams were to be provided with locks, so that they might help and not obstruct navigation. I have not made the proposed estimates, however, as I have since learned that the ice from the Licking is always sufficiently broken up by the banks before it reaches the Ohio,

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and that the ice that did the great damage in 1856 was in small cakes. (The Commercial speaks of it as crossing the Ohio "in huge fragments;" this, however, is doubtless a reporter's exaggeration, as my information comes from a very intelligent steamboat-captain who was an eye-witness of the break-up.)

The difficulty with this river arises from its heavy slope and its sudden floods, both of which causes are apparently beyond human control There is, however, an excellent work that can be done for the improvement of the Licking, which is also essential to its use for a harbor of refuge, in the removal of the rock bar that now obstructs its mouth.

This would greatly add to the available wharfage of this port by opening up a place for the unemployed steamboats which now encumber the present landings, and which, as things are now, do not dare to enter the Licking on account of the uncertainty of being able to get out when they are wanted.

A comparison of the map with the profile will show this bar very plainly. I have made estimates for two routes and two different depths of water. The shortest cutting is not the one which I would recommend, as it would operate to direct the current of the Licking straight to the Cincinnati landing, where it might cause injury to boats, especially during ice floods. The longer channel curves gently down stream and directs the Licking current into the middle of the Ohio.

Should the cut be made to give 6 feet at low water, it would make the Licking accessible, during the lowest stages, as far up as the Licking Iron-Works. At present, during the low water, there is but 0.6 foot on the bar at the mouth. The greatest depth of cutting would, therefore, be 3.4 feet for a 4-foot channel, and 5.4 feet for a 6-foot channel. It is difficult to estimate the cost of this work, as so much depends upon the condition of the river during the summer. The last contracts for work on the Chain in the Mississippi, at Rock Island, varied from $8 per cubic yard to $14.50.

It is thought that local circumstances here are more favorable than they were there, and, therefore, I have chosen the lowest of these prices as the probable cost of similar work here. Both of the indicated channels are 200 feet in width at the mouth of the river, being wider than the river itself a little above the mouth, and thence widening gradually into the deep water of the Ohio. The shorter and more direct channel is about 1,200 feet long, while the curved and better channel has a length of about 1,600 feet. The rock through which the channel will have to be cut is the ordinary stratified limestone of this locality, and presents no difficulty in working. To make the shorter channel, with a depth of 4 feet at low water, it will be necessary to remove 19,878 cubic yards of rock; for a depth of 6 feet, 39,650 cubic yards must be removed. For the curved channel, which I prefer, 26,586 cubic yards of rock excavation would be needed for a 4-foot channel, and 53,185 cubic yards for a 6-foot channel.

Tabularly stated, the comparison is as follows:

	Depth at low water.	Yards of rock excavation.	Cost of rock excavation.	Contingencies and engineering, 5 percent.	Total cost.
Straight channel	4 feet...	19,878	$159,024	$7,950	$166,974
Do	6 feet...	39,650	317,200	15,860	333,060
Curved channel	4 feet...	26,586	212,688	10,134	222,822
Do	6 feet...	53,185	425,480	21,274	446,754

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As the removal of this bar is an essential part of any plan for making a harbor of refuge, it being almost a *sine qua non* that there should be free access to the harbor at all stages of water, it is proper that the cost of removing this bar should be added to the previous estimates for a basin. We therefore have the following estimates for the entire work necessary to make a harbor of refuge in the Licking, near its mouth:

Estimates for harbor of refuge in the Licking, near its mouth.

	Estimated cost.	Straight channel over bar.		Curved channel over bar.		Gross cost of entire work.
		Four feet.	Six feet.	Four feet.	Six feet.	
Small basin, with walls	$752,640	$166,974				$919,614
Do	752,640		$333,060			1,085,700
Do	752,640			$222,822		975,462
Do	752,640				$446,754	1,199,394
Small basin, with slopes	351,539	166,974				518,513
Do	351,539		333,060			684,599
Do	351,539			222,822		574,361
Do	351,539				446,754	798,293
Large basin, with walls	1,178,040	166,974				1,345,014
Do	1,178,040		333,060			1,511,100
Do	1,178,040			222,822		1,400,862
Do	1,178,040				446,754	1,624,794
Large basin, with slopes	574,119	166,974				741,093
Do	574,119		333,060			907,179
Do	574,119			222,822		796,941
Do	574,119				446,754	1,020,873

A careful examination of this table will show that on any plan the cost of the combined works indicated is very great; and when we consider the fact that the loss from the most disastrous break-up was only estimated at $100,000, which was, probably, in excess of the fact, and that the average annual loss will not, probably, exceed $10,000, it is a question whether it would not be better to pay the sum annually rather than expend so much upon a work of doubtful utility. Even should the basin be constructed, there will always be boats at the wharves, some of which will be caught there while loading or unloading, and others will stay there by choice, taking the chances of a safe break-up in order to save time and get their cargoes aboard, so as to start out the moment the river is clear.

If Congress decides to make an appropriation for the improvement of the mouth of the Licking, I would recommend that it be limited to the removal to a depth of 4 or 6 feet of the rock-bar, selecting the curved channel as the one to be constructed.

For a 4-foot channel, $222,822 would be needed, and for a 6-foot, $446,754. The removal of this bar would be of great local advantage, as it would furnish a good low-water harbor for unemployed boats, thus freeing the city wharves, and it would make available for repairing-docks, and for other manufacturing establishments, 5½ miles of water-front, now but little used on account of the bar at the mouth of the river. It would be of such advantage to the two cities of Covington and Newport that they would, probably, be willing to assist in the work. Three sheets of maps, on a scale of 1 inch to 200 feet, accompany this report, as also one sheet showing the longitudinal profile of the three miles under examination.

Respectfully submitted.

WILLIAM E. MERRILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

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K 5.

WATER-GAUGES AND PROTECTION OF THE BANKS OF THE MISSISSIPPI.

OFFICE OF THE OHIO RIVER IMPROVEMENT,
Cincinnati, Ohio, February 19, 1872.

GENERAL: I have the honor to submit the following report on the establishment of water-gauges on the Mississippi and its tributaries:

The resolution of Congress, approved February 21, 1871, reads as follows:

Resolved, &c., That the Secretary of War be, and he is hereby, authorized and directed to have water-gauges established and daily observations made of the rise and fall of the Lower Mississippi River and its chief tributaries at or in the vicinity of Saint Louis, Cairo, Memphis, Helena, Napoleon, Providence, Vicksburgh, Red River Landing, Baton Rouge, and Carrollton, on the Mississippi, between the mouth of the Missouri and the Gulf of Mexico, and at or in the vicinity of Fort Leavenworth, on the Missouri; Rock Island, on the Upper Mississippi; Louisville, on the Ohio; Florence, on the Tennessee; Jacksonport, on the White River; Little Rock, on the Arkansas; and Alexandria, on the Red River; and such other places as the Secretary of War may deem advisable, the expenditure for the same to be made from the appropriation for the improvement of rivers and harbors: *Provided*, That the annual cost of the observations shall not exceed the sum of five thousand dollars per annum.

This work was assigned to me on the 23d of March, 1871. At that time the Mississippi was in flood, the great Bonet Carré crevasse, above New Orleans, being in active operation. After carefully studying the subject, I concluded that it would be useless to attempt the establishment of water-gauges that answer any useful purpose until the river got to its lowest stage. The records of the Delta survey showed that the gauges then used were constantly carried away by floods and drift, and, as the object of re-establishing them had been officially stated to be the collection of *continuous records for a series of years*, I concluded that it would be better to delay the work until I could do it satisfactorily. For these reasons I did not commence operations until August, at which time the Ohio, Missouri, and Upper Mississippi were low enough to justify the establishment of the northern gauges. After making arrangements for gauge-records at Louisville, Saint Louis, Fort Leavenworth, and Rock Island, I was compelled, by the exigencies of my work on the Ohio, near Pittsburgh, to visit that city. I was, therefore, unable to commence establishing the southern gauges until the middle of October. From that time I was constantly engaged on this work until the middle of January, when I returned to my station in this city. The resolution of Congress called for the establishment of seventeen gauges. I actually established nineteen, an extra one at Louisville, as gauges are required both for the head and the foot of the falls, and one at Natchez, which was specially requested by the river interest. An additional variation from the designated localities was the establishment of a gauge at the mouth of White River instead of at Napoleon. My reasons for this change were that half of Napoleon has been washed away, including all the old bench-marks; that very few steamboats stop there now, and that the old mouth of the Arkansas has so nearly filled up as to be unnavigable except in high water, the river now emptying into the White through the cut-off, which has become the mouth of the Arkansas. All steamboats for the White or Arkansas now enter the mouth of White, and one of the great coal-fleets is now moored there for their accommodation. A gauge at Napoleon would scarcely ever be seen, while almost every steamboat lands at the mouth of White, which is now one of the greatest stopping-places on the Mississippi. With these exceptions I have complied exactly with the resolution of Congress.

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The question of the available means of making permanent marks on a river like the Mississippi is one that is surrounded with difficulties. There is nowhere any structure in the river, like the piers of bridges, to which gauge-rods can be attached, and, excepting at Vicksburgh and Carrollton, there is nowhere any building extending into the river beyond the high-water mark. Moreover, at most places the bank is being constantly washed away by undermining or by abrasion, or else being cut off from the water by immense and rapidly-formed sand-bars, and the range of the river is never less than 40, and sometimes is over 60 feet. It became evident at once that none of the ordinary tide-gauge arrangements would answer, but that the problem would have to be solved by devices specially adapted to the river in question.

The two objects for which the gauges were designed, as pointed out in the letter of General Abbot of March 2, 1870, were to secure information in high water that would help in the solution of the levee problem, and to give reliable reports of the river, in average and in low water, for the benefit of the steamboat interest. I therefore determined to locate the gauges, if possible, where they would be easily accessible to the public, and to so construct them that they could be read with facility at any hour of the day or night without the use of a skiff. To secure the latter object, I decided to construct the gauges on the surface of the levees, or of the natural banks, marking them by an engineers' level after they were fastened in place. The question of marking was one that troubled me greatly, as it was evident that mere painting in black and white would soon be useless after the gauge was once or twice covered by the muddy waters of the Mississippi. Fortunately, Mr. Charles Thruppe, the city engineer of Cairo, suggested tacks, and thus removed my most serious difficulty.

My general method of construction was as follows: The gauge-plank, of oak, yellow pine, or cypress, was 6 inches wide and 3 inches thick, and in lengths of from 16 to 24 feet. The upper surface received two coats of black paint, and each stick was thoroughly oiled on all sides. The gauge planks and posts for all places below Memphis were Fominized (?) before being used. The planks rested on 4 by 4 inch posts of oak, yellow pine, or cypress, from 4 to 5 feet in length, and placed 5 feet apart. It being necessary to mark the lowest piece of the gauge before it was placed in the water, posts were first driven into the bank by sledges, or by a hole-digger, until their tops were about 4 inches below the general surface of the bank, the lowest post being in the water 1 or 2 feet from shore. These posts were then sawed off on any convenient grade, and the amount of this grade was determined by the level. The lowest gauge-plank was then carefully marked in accordance with this grade. The method of marking was as follows: A space, $2\frac{1}{2}$ inches in width, was first laid off on the right side of the plank by a carpenter's gauge. This gave the amount of space to be occupied by tenth-marks. The lowest foot-mark (1 or 2 below zero, if possible) was then scribed across the lower end of the plank about 2 inches from the end, and from this the other foot-marks were laid off by the tape-line and scribed. The intervals between the foot-marks were then evenly spaced by dividers into ten equal parts, which were scribed across the $2\frac{1}{2}$ inches laid out for tenths. Each foot was then permanently marked by eleven white tacks (10-ounce silver lining-nails) driven on the scribed line, and its number was similarly marked in Arabic numerals placed just above the line. Each tenth was marked by five copper tacks ($\frac{5}{8}$-inch copper tacks, Wallace & Sons) on the appropriate lines, one extra tack outside the line being allotted to each half-foot mark. No numbers were marked

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on the tenths. The gauge-plank thus prepared was placed upon the posts and shoved into the water, until the proper reading above low water was obtained; it was then firmly fastened by 7-inch spikes, two to each post. The height of the water-surface above low water was procured from the best local evidence attainable, it being the intention always to put the zero at low-water mark. It should be stated, however, that in many cases the river, subsequently, fell below the zero of the gauge, which was sometimes due to inaccurate information, but generally arose from the fact that during last December and January the Mississippi at most places attained a lower point than had ever been known before.

After the lowest section of the gauge was in place the other sections were fastened in position before marking, care being taken to have the surface of the plank on a level with the bank, so as to remove any danger of injury by drift or floating ice. The level was then placed on one side and the reading of the highest foot already marked was obtained; the target was then lowered 1 foot and the rod was moved up the gauge until the point 1 foot higher than the last marked foot was reached. The other foot-marks were similarly determined, and the spaces between were evenly divided into tenths. As each section of the gauge had its own grade, it was necessary to mark the half foot by the level wherever the grade changed. The half foot containing the joint was divided into tenths by using on each plank the interval found for the nearest foot or half foot.

The high-water marks were obtained from the most accurate marks to be found in the vicinity, and were transferred to the gauge, on which they were marked with white tacks, on the sides, if the upper section was vertical, and on the face if it was inclined. Wherever the bench-marks of the Delta survey could be found they were referred to the gauge, and full descriptions of all bench-marks, their readings on the gauge, and the readings of the low and high waters, were recorded in the record-books of each station.

Observations were made at each station at 8 o'clock every morning, and at the end of each week a copy of the record for the week is forwarded to this office on suitable blanks, specially prepared, of which copies are on file in the office of the Chief of Engineers. Each weekly report shows the gauge-reading, the height above the lowest water known, the distance below the highest water known, and the force and direction of the wind. In the record-book space has been left to record all kinds of river information that may prove generally useful, such as depth on bars, crevasses, cut-offs, ice-gorges, &c., which may be valuable in the future discussion of the results attained.

DESCRIPTION OF THE GAUGES.

Fort Leavenworth guage.—I am indebted for the construction of this gauge to Lieutenant E. H. Ruffner, Corps of Engineers, chief engineer Department of the Missouri. It is in two sections, of which the upper is located 165 feet below the pumping-engine house, and the lower 390 feet below. The latter is bolted and braced to a frame of heavy timbers, its lower end resting on the bed-rock of the river. The high-water section is 225 feet above the lower, and reads from 12 feet upward. The zero of the gauge is 2.89 feet below the low-water mark of November, 1871, the lowest known. High water, 1867, the highest known, reads on the gauge 18.13. The bench-mark to which the gauge is referred is the high water of 1867, permanently cut into the rock near the engine-

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house. The maximum oscillation of the Missouri River at this locality is therefore 21.02 feet. Both sections are of wood, painted black, with the marks indicated by white and copper tacks. The gauge of the Kansas and Missouri Railroad bridge, which has been kept for two and a half years, is about three-fourths of a mile below, and is placed on one of the channel-piers. The zero of the new gauge reads 105.34 on this gauge. Mr. W. N. Nutz is the water-gauge observer.

Rock Island gauge.—This gauge is cut into the stone pivot-pier of the new United States railroad and highway bridge, and for its construction I am indebted to Colonel Macomb and Captain Stickney, of the engineers. It is placed on the upper side of the pier, inside of the wooden pivot-guard, and is reached by a ladder. The zero of the gauge is at the low-water mark of 1864, and it is identical with the zero of the bridge level. High water (April, 1870) reads 16.7 on the gauge. The maximum oscillation is therefore 16.7 feet. Mr. A. M. Scott is the observer.

Saint Louis gauge.—As the city of Saint Louis has been in the habit for many years of having the stage of the river taken daily by an engineer with a level, I did not construct a gauge at this locality, but contented myself with making arrangements for securing a copy of the city record. I think, however, that a gauge that could be read by every one at all hours of the day or night would be much better than the present system, and since my return from the South I have urged the city engineer, Mr. J. B. Moulton, to establish one after the model of the Memphis gauge. I believe that it will ultimately be done, though the preference seems to be for a gauge on one of the piers of the new bridge.

The principal Saint Louis bench-mark is the curb-stone of the levee between Market and Walnut streets, which is the high-water mark of 1826, and has been taken as the city directrix and the zero of the gauge. It is 33.81 feet above low water of 1863, 7.58 feet below high water of 1844, and 3.28 feet below high water of 1855. The maximum oscillation is therefore 41.39 feet. Mr. Jacob Leopold is the observer.

Cairo gauge.—This gauge is located by the side of the upper inclined railway of the freight-landing of the Illinois Central Railroad. This seemed to be about the only place where permanency of bank could be secured without danger of injury to the gauge by vehicles. The total length of the gauge is about 250 feet, the slope of the levee being very gentle. It is continuous from below low water to above high. The zero of the gauge is one foot above low-water mark of December 24, 1871, the lowest known. High water of 1867 reads 50.97. The maximum oscillation is therefore 51.97 feet. The zero of the city levels reads on the gauge 9.18. The range of the gauge is from 1 to + 53. The bench-mark to which it is referred is the high-water mark of 1867, which is cut on one of the foundation-stones of the freight-house, on the east side of the lower railway track. The observer is the city wharf-master, Mr. M. S. Ensminger.

Upper Louisville gauge.—The lower portion of this gauge is cut into the north abutment-wall of the upper guard-gate at the head of the Louisville and Portland Canal; on this it reads to 20.60. The high-water portion of the gauge is attached to a cotton-wood tree on the north bank of the canal, opposite the foot of Ninth street. The zero of the gauge is 1 foot above the bottom of the canal at its head. The low water of 1856, the lowest known, reads on the gauge 1.17. The high water of 1832, the highest known, reads on the gauge 40.83. The maximum oscillation is therefore 39.66 feet. The zero of this gauge is at the reference 35 by the canal levels. The depth over

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the falls, as reported in the newspapers, is obtained by subtracting 2 feet from the gauge-reading. The observer is Captain E. Lockhart, the canal superintendent.

Lower Louisville gauge.—The lower portion of this gauge is cut on the tail wall of the double lock at the foot of the Louisville and Portland Canal. The upper portion is cut in the canal wall above the double lock, and below the lower guard-gate and the lower bridge The zero of this gauge is 2 feet above the lower miter-sill of the double lock, and its reference by the canal-levels is 8, which makes it 27 feet below the zero of the upper gauge.

Low water of 1856 reads on this gauge 1. High water of 1832 reads 67.5. The maximum oscillation at the foot of the canal is therefore 66.5 feet. The observer is Captain E. Lockhart, the canal superintendent, who keeps the record of both gauges.

Both of the Louisville gauges were constructed at my request, under the direction of Major G. Weitzel, engineers, by his assistant, Mr. Philip J. Schoff.

Florence gauge.—This gauge is located just below the north abutment of the railroad-bridge over the Tennessee River, the upper portion of the gauge being on the abutment. Plank and posts are of yellow pine. The zero is the low water of 1871, and the range of the gauge is from .4 to + 33.8. High water of 1867, the highest known, reads on the gauge 31.08. The maximum oscillation is therefore 31.08 feet. The bench-marks are the southwest corner of the top of the first small pier, north of the bridge, which reads 30.193, and the top of the northwest corner of the bridge-seat on the abutment, which reads 32.261. The observer is Mr. W. P. Stradford.

Memphis gauge.—The old gauge of the Delta survey was located in the Wolf River, a short distance above its mouth. I decided not to re-establish the gauge in the old locality, on account of its inaccessibility, believing it politic to risk injury in order to secure usefulness. I therefore placed the gauge on the steamboat-landing, at the foot of Court street. The lower slope of the Memphis levee is so steep that no freight can be placed upon it, nor can vehicles drive over it. On this slope I made the usual plank and tack gauge, trusting that the city might be induced to extend the gauge through the levee to high-water mark. The city engineer, Major J. H. Humphreys, and the harbor committee, very cordially co-operated with me, and, through their endeavors, the city was induced to complete the work, for which my funds would not suffice. In extending the gauge through the traveled portion of the levee, it was essential to devise some plan that would permit the gauge to be crossed by heavy vehicles without injury. Our consultations resulted in the following arrangement, whose description I quote from one of Major Humphreys's letters, the extension having been made since I left Memphis:

> The marks are cut upon a bar of iron 4 inches by ½ inch, which rests upon an oak beam, 5 by 14 inches, to which it is spiked about every 2 feet with 4-inch wrought spikes with countersunk heads. The oak beam rests upon 6 by 6 cross-pieces, and these upon 4 by 5 short oak piles, 4 to 5 feet long, driven into the ground by an oak beam used as a rammer. The cross-pieces are 6 feet apart, and the piles under them 3 feet apart, two under each. The top of the girder is notched on the cross-pieces. The iron bar is graduated to tenths, the longest marks being for feet, the next for half-feet, and the short ones for tenths. The foot-marks are Arabic numerals placed so as to read in the direction of the lengths. The tenths are not figured, except at the half-foot, which is designated by a figure 5, smaller than the foot-marks, and placed so as to be read across the gauge.

This portion of the gauge is farther up the river than the other, being

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about 120 feet south of the south line of Jefferson street. I have no hesitation in saying that Memphis has now the best water-gauge on the Mississippi, or any of its tributaries.

The zero of this gauge is .92 above low-water of December 29, 1871, the lowest ever known, and it is 66 by the city levels. The range of this gauge is from 1 to + 36.

High water of 1858 reads 34.278. High water of 1867 reads 34.80. The maximum oscillation is, therefore, 35.72 feet. The gauge observer is Mr. W. L. Trask, the river reporter of the Memphis Avalanche.

The bench-mark of the old Delta-survey gauge has been destroyed, but a portion of the water-table of the rope-walk of the old navy-yard is still in place. It reads by the city 111.338, and therefore on the new gauge 45.338. The distance of the new gauge below the mouth of Wolf River is 2,450 feet. Finding much difficulty in getting the proper material for gauges, I concluded to lay in a full stock of lumber and tacks at Memphis, and take them with me down the river. All of this lumber was Formingized (?) before starting, and would have been painted but for the stupidity of one Johnson, a carpenter whom I employed to get everything ready while I was constructing the gauges at Jacksonport and Little Rock. His neglect caused me much trouble, but fortunately no serious delay. It may be worth mentioning that I used up on the gauges about 55,000 tacks.

Jacksonport gauge.—This gauge was placed at the northern end of the town, below Weisel's saw-mill, and opposite a brick house owned by Mr. L. C. Ganse, on Jefferson street, between Main and Mill. It is about two squares above the steamboat-landing, no other locality apparently possessing a bank of sufficient stability. The high-water section is on Ganse's house. The zero of the gauge is at the low-water mark of 1871, and its range is from 1 to + 35. The high water of 1867 reads on the gauge 32.826, and this is therefore the maximum oscillation. A bench-mark of five copper tacks has been established on the southern end of the sill of the southern door, at the rear of Mr. Ganse's building, which reads on the gauge 31.692. Mr. W. E. Bevens is the observer.

I would remark here that the deficiency in the number of bench-marks for this gauge, and for many others, was due to the pressing necessity of establishing all the gauges with the utmost rapidity in order not to lose the low-water season. I intend on my next annual trip to increase the number of bench-marks at all stations, a duty which I thought could be safely postponed, as in most cases the high-water sections of the gauges are so securely fastened and so distant from the bank that they are themselves excellent bench-marks.

Little Rock gauge.—The Arkansas River being comparatively high when I reached Little Rock, and time being pressing, I did not wait to put in the gauge myself, but made arrangements with Major S. McCormick, formerly city engineer, to have him attend to it, leaving with him detailed instructions in writing. Work was delayed for some time by the serious illness of Major McCormick, and the completion of the permanent gauge has been still further hindered by the necessity of waiting for the paving of the public landing. The gauge is placed about 150 feet below first rocky point, (the Little Rock,) and the lower section is fastened to the vertical timber retaining-wall of the wharf, which rises to the height of 5 feet above the low-water mark. The gauge is temporarily extended to high water by rods near the rocks. It is the intention to make the middle section along the surface of the landing, as soon as the latter is paved, and to fasten the high-water section to a brick house in the vicinity.

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The zero of the gauge is the low water of 1864, the lowest known. High water of 1857 reads on the gauge 31, which is, therefore, the maximum oscillation. The permanent bench-marks have not yet been established. The top of the retaining is a temporary bench, and it reads on the gauge 5.1. The observer is Major S. McCormick.

Helena gauge.—A very large sand-bar is yearly making in front of the city of Helena, and it was therefore necessary to establish the gauge a short distance below the city, that it might not be buried in sand, or cut off from water in low stages. It was placed near the coal-landing, and what is the wharf boat-landing in moderate stages, being on the southern line of Mr. A. Fink's lot. The lowest section is inclined, extending to the top of the bank. Three short sections are attached to as many cypress-stumps, and the fifth or high-water section is back on the exterior slope of the levee. The vertical sections face toward the bank, and the reading can readily be taken in any stage of water, without the use of a skiff.

The zero of the gauge is 1.05 feet above the low water of December 29, 1871, the lowest ever known, and the range of the gauge is from 2 to + 43.5, (about 2 inches below the top of the levee.) High water of 1862 reads on the gauge 44.203; of 1867, 43.62; of 1858, 42.411; of 1859, 40.994. The maximum oscillation is, therefore, 45.253. It will be seen from the high-water reading of 1862 that another such flood would overtop the levee. The bench-mark of this gauge is the top of the first projecting course of bricks of the southern foundation-pier of Mr. Fink's house, which reads on the gauge 40.89. Mr. James B. Miles, the editor of the Helena Clarion, is the observer.

Mouth of White River gauge.—For reasons given in the first part of this report, I decided to put the gauge here rather than at Napoleon. It is placed about 100 yards below the town, opposite the coal-fleet of Mr. W. H. Brown. It is the usual inclined gauge, the highest section being fastened to the bell-post of the coal-yard. The zero of the gauge is 1.833 feet (22 inches) above the low water of December, 1871, and the range of the gauge is from 0 to 47.3. High water of 1867 reads on the gauge 43.6, and the maximum oscillation is therefore 45.433 feet. The bench to which it is referred is five copper tacks in the nearest check-post above the gauge, and it reads on the gauge 45.57. The observer is Mr. W. M. Ezell, the agent in charge of the coal-fleet. There is no levee at this place.

Lake Providence gauge.—This locality is particularly bad on account of caving banks. The best place that I could find was opposite Mr. Le May's house, (since destroyed by fire,) and about 100 yards below the canal cut by the United States forces during the late war. A small sand-bar has formed here, while at all other accessible places the bank is washing badly. The harbor of Lake Providence has been almost destroyed by a huge island bar, partially connected with the Louisiana shore above, that compels the wharf-boats to lie almost one mile below town when the river is low. The zero of this gauge is 2.9 feet above the low water of January 2, 1872, and the range of the gauge is from 0 to + 45. High water of 1862 reads on the gauge 40.87; of 1867, 39.99. The maximum oscillation is 43.77 feet. The temporary bench that was established here has since been destroyed by fire. The old United States bench had been destroyed before my arrival, but not before it had been transferred to another bench-mark. I could not ascertain the exact facts about this transfer, and therefore made arrangements with General Jeff. Thompson, the State engineer of Louisiana, to have the correction made at some future time by one of the levee en-

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gineers. There is but little likelihood of injury to the gauge before this is done, as the upper section is on the old levee at some distance from the present bank, and will itself answer temporarily as a bench. The observer is Mr. S. T. Le May.

Vicksburg gauge.—The river-bank along the whole front of Vicksburg is unstable, owing, in all probability, to its super-position upon a slightly inclined stratum of hard clay. The only exception seems to be just behind the Prentiss House, where it is held by the piles of an elevator, which extends into the river almost to low-water mark. The lowest section of the gauge is inclined, and extends into the water from the outer line of the elevator. Eight other sections are fastened to the piles of the elevator in such a manner that each section can readily be read during the stage of water which it records. The highest section of all is fastened to the brick wall of the Prentiss House, at its northwestern corner, about 6 feet from the old bench-mark. The hotel is said to rest on solid rock except at the southwestern corner.

The zero of the gauge is .5 above the low water of January 1, 1872, and the range of the guage is from +1 to +53. The stage of water at the time of construction, and the very gentle slope of the bank, did not permit me to extend the gauge to 0, or below it. High water of 1862 reads on the gauge 51.104; of 1867, 49.021. The maximum oscillation is 51.604 feet. The old bench-mark of the Delta survey is close to the new gauge and reads on it 46.652. The observer is Mr. H. G. Fairchild, of the Merchants' Wharf-boat.

Natchez gauge.—Although Natchez was not on the list of places at which gauges were ordered, I thought it best to make a station here in deference to the wish of steamboat-pilots, and my own conviction that the distance between Vicksburg, and Red River Landing was too great to be left unoccupied. The old United States gauge was located above Brown's mill, but this was so far from the steamboat-landing that I thought it best to occupy a more accessible locality. I found an excellent place just below the Natchez and Vidalia ferry landing. At low water there outcrops a stratum of indurated clay which gave a very good foundation for the low-water section. An inclined gauge was constructed here, but as it was impossible to drive posts, it was fastened by 3-foot bolts, of inch iron, driven up to their heads in the clay. The third plank of the gauge rested on gravel overlying this clay, and its upper end was held by a 6-foot bolt, 3 feet of which went through gravel, and the rest into the clay. The low-water section of this gauge is not excelled by any on the river.

The zero of the gauge is the low water of 1871, and the range of the gauge is from 2 to + 48.3. No high-water mark that could pretend to accuracy could be found near the gauge, and it was thought best to leave this and the connection with the old United States gauge (at Brown's mill, one and one-half miles above) to be settled by simultaneous observations at the two places during the next high water. By this means an accurate connection could be made without the necessity of considering the slope of the water between the two stations. The bench-mark of this gauge is a copper tack driven into the southwest end of the door-sill of Mr. Cann's house, near the ferry. It reads on the gauge 50.207. The observer is Mr. R. B. Monteith, of the wharf-boat.

Red River Landing gauge.—A large dry bar having completely cut off the locality of the old United States gauge from the river at low and ordinary stages, it became necessary to put the new gauge about a mile and a quarter below, near the present harbor of the wharf and coal boats.

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No vestige of the old United States bench remains. The gauge is inclined, and the upper section is on the old levee; the new levee at this place being retired about 150 yards.

The zero of the gauge is 1.25 feet above the low water of January 2, 1872, and the range of the gauge is from 2 to + 43.5. High water of 1867 reads on the gauge 43.332; of 1871, 41.51. The maximum oscillation is 44.582. The bench-marks are five copper tacks at the west end of the northern door-sill of Kingsbury & Smith's stable, which reads on the gauge 41.645, and five eightpenny nails driven in a horizontal line into a large cotton-wood tree, about 80 yards northwest of the top of the gauge, reading 43. The observer is Major A. D. Smith, one of the proprietors of the wharf-boat.

Alexandria gauge.—This gauge was placed a few feet below the warehouse of Captain J. A. Williams. It is inclined excepting the highest section which is fastened to a heavy post set up for this purpose. The zero of the gauge is the low water of August, 1871, and the range is from + 2 to + 40.5. The high water of the river prevented the gauge from being extended to low water, as was wished. It is thought that the downward continuation of the gauge may be accomplished without trouble during the next low water. High water of June, 1866, reads on the gauge 36.46, which is also the maximum oscillation. The bench-mark is a metal star on the south end of the iron sill of the north door of the Ice-house Hotel, which reads on the gauge 35.853. Captain John A. Williams is the observer.

Baton Rouge gauge.—This is the worst place that I found on the whole river for establishing a water-gauge. The bank along the whole front of the city is unstable and constantly slides down. The only exception seemed to be for a short distance below the old saw-mill, about two squares below the state-house, and therefore I chose this place for the gauge. The old gauge was above the United States barracks, and about one mile above the present site. I judged it best to connect the two gauges by the recorded height of the flood of 1858, for which, and other valuable information, I am indebted to Mr. William Waller, civil engineer. The gauge is the usual inclined one, the upper section being on the bank on the levee. Its zero is at the low-water mark of 1854, the lowest ever known, and it ranges from + 1 to + 36.3, the slope of the bank making it impossible to read to zero.

High water of 1862 reads on the gauge 35.875; of 1858, 34.627; of 1851, 34.335; and of 1871, about 35, (not accurately known.) The maximum oscillation is 35.875 feet. The bench-mark was taken at the state-house, and is the top of the lowest marble course of the northern tower of the western front. It is a well-known bench-mark for levees, throughout this region, and also for city work, and it reads on the gauge 62.375. The observer is Colonel S. H. Lackett, of the Louisiana State University.

Carrollton gauge.—At this place I thought that, as many difficult problems had been discussed by the readings of the old gauge, and many more might come up on account of the complicated relations that exist here between the tides and storms in the Gulf, it would be better to re-establish the old gauge, although the old records showed that the zero was .7, too high for low water. The construction of a wharf at Carrollton made the securing of the gauge an easy matter. It is fastened to different piles of the wharf, and can readily be read at all stages. The range of the gauge is from 1 to + 16.4, the river being at its lowest point when the gauge was fastened. High water of 1871 reads on the gauge 15.4; of 1862, 15.358; (this I consider uncertain, the

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report being that it was a half inch lower than 1871.) The maximum oscillation is 16.1. The bench-mark of this gauge is the well-known Hampson bench, which reads on the gauge 7.92. Mr. W. L. Duffy is the observer.

It should be mentioned that the effect of the Gulf tides is very palpable at Baton Rouge in low water, and it is even noticed to the amount of 2 or 3 inches at Red River Landing.

Recommendations.—To make these observations as serviceable as they should be, both for steamboats and planters, it is desirable that daily reports should be made by telegraph, as is now done with weather reports.

In order to estimate for the cost of so doing, I applied to the President of the Western Union Telegraph Company, requesting him to send me an estimate. He has replied by giving me a schedule of rates in accordance with which the cost of reporting to Cincinnati from the fifteen stations that have telegraph-offices would be about $3,121 per annum. No estimate is made for distributing this information from Cincinnati, as it is believed that the Associated Press would do this gratuitously. If they declined to do so the additional cost would average as many times $3,000 as the number of places selected. It should be stated that, at the mouth of White River, Lake Providence, Red River Landing, and Alexandria, there are no telegraph offices, though efforts are being made to secure such at the mouth of the White and of the Red, both of which are very important commercial points.

Disbursements and estimate.

The cost of establishing the gauges, including mileage, has been to date..	$1,358 96
For contingencies, including Little Rock gauge, there should be allowed..	300 00
For salaries, and observers and clerks, to January 30, 1872.....	2,027 67
Total probable expenditure to end of fiscal year.....	3,686 63
Appropriation.....	5,000 00
Probable balance at end of fiscal year.....	1,313 37
Estimated expenditure for next fiscal year.....	$4,500 00

As it is desirable that the system should be extended as much as possible, I would recommend that this appropriation be increased to $11,000, ($3,000 of which is for telegraphing,) and that the Chief of Engineers be authorized to extend the system to such places as may in his judgment require its benefits. The Cumberland, Illinois, Ouachita, and Wabash ought all to have water-gauges, and other points on the rivers already supplied might be chosen with advantage.

PROTECTION OF THE BANKS OF THE MISSISSIPPI.

The duty of establishing water-gauges made it necessary for me to examine the banks of the Mississippi at low water throughout its length, and this made me familiar with the great injury that has been, and is now being produced by the unimpeded and ceaseless action of this great body of water. I think that this most injurious condition of affairs may be remedied without extravagant outlay, and the object proposed is so important that, although in a measure foreign to the object of this report, I think it my duty to present it for examination.

As matters stand at present the river moves from bank to bank without the slightest effort being made to prevent it from undermining and

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destroying towns, levees, and plantations. This state of affairs makes all property on the Mississippi uncertain, and history shows that without permanence of home and occupation it is impossible to construct a high civilization. Man will not thoroughly improve what may at any time be destroyed by causes beyond his control.

The laws that govern the Mississippi are identical with those that prevail in all streams, however small, that flow through unstable soils. As the Rhine, the Po, the Vistula, and Garonne, have been curbed and guided through regular channels, so may also the Mississippi. The question is not one of science, which has long since decided upon its methods; it is now one of finance. Can the improvement be made at a reasonable cost? This is the question which I propose to discuss.

As far as I could learn, after careful examination and inquiry, the greatest injury by abrasion is due to action below low-water mark. If this can be stopped, the mere surface abrasion above low water would ultimately cease when the grade of the bank had reached a certain slope, probably four base to one perpendicular. It is an undoubted fact that, after a season of high water, when the banks have become thoroughly saturated, a fall of the river is generally accompanied by a corresponding fall of steep banks. This, however, is a secondary result of the undermining below low-water mark, which is perpetually restoring the steepness of fallen banks by continually removing their bases. Were this undermining stopped, banks would soon be worn down above low-water mark to a stable slope, and then all injurious action would cease. Hitherto, as far as I have been able to learn, whatever efforts have been made to protect the shores of the Mississippi, have been limited to the space between high and low waters, the very part that, in my opinion, requires no protection. In many localities the banks of the Ohio, between low and high water, are very similar to those of the Mississippi, and this portion is equally exposed to abrasion, but the existence of a firm subsoil makes the action comparatively innocuous. Reasoning by analogy we should therefore infer that if similar conditions could be artificially established on the Mississippi, a similar freedom from destructive wash would prevail.

Assuming, then, that undermining below low water is the cause which we wish to control, the next question is that of means.

The alluvial nature of the Mississippi Valley makes the use of stone, except in very rare cases, impossible on account of its excessive cost. As a general solution of the problem it need not be considered. Wood is practically indestructible when permanently under water, and as it is abundant throughout the valley, it at once settles the question of material, provided its use be practicable.

It should be mentioned here that it should be laid down as a principle that the protection of a bank that is vertical, or nearly so, should not be attempted. Either the bank above the water should be graded off and the material be thrown in until a reasonable grade is assumed, or else we should wait until nature does the same thing by undermining. Our work should not commence until the slope to be protected ceases to be excessively steep.

The conditions to be fulfilled are, that the material used shall be durable; that it shall be flexible, or otherwise adapted to an irregular surface; that it shall not be costly, and that it shall be susceptible of easy application. All of these conditions are met by the following construction, and for the purpose of getting practical figures let us take the problem which is now pressing upon us, of the protection of the peninsula opposite Vicksburg. For figures I turn to the very admirable report of

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Major Suter, of the Engineers, dated February 6, 1871, with which I fully agree, except in the one item of using stone for a revetment. The only, but unfortunately the insuperable, objection to that material is its excessive cost. The bank to be protected is 21,000 feet in length, and the maximum depth of water is 67 feet at low water. It will, therefore, be reasonable to assume that if a protection 200 feet wide be extended into the river from low-water mark it will reach the channel and rest on the hard clay of the true river-bed.

The method of protecting would be by what is known in fortification as hurdle-work. I would cause continuous hurdles, 3 feet wide and 200 feet long, to be constructed, and I would fasten these together in sets of fifty, thus making what might be called a carpet of hurdle-work 200 feet long and 150 feet wide. Into these I would tie, by withes or wire, short branches of trees until it became, as it were, tufted over its entire surface. These branches would protect the main structure and assist the deposition of sand and gravel. I would then firmly attach one side of this hurdle-carpet to the shore at or near the low-water line, and, by boats, steam-tugs, or anchors, I would hold it in position, at right angles to the shore, until it had been sunk into place by weights. For these latter I would use stone, if it could easily be obtained, or rough baskets filled with clay, or old bricks, or loaded fascines, or water-logged timber, or any similar weighty material that might be convenient. These carpets should be sunk in succession from the uppermost point to be protected. Should a very rough place be found, where snags, &c., made it difficult to adjust the carpet, I would either have them removed by a snag-boat, or else protect it independently by a mass of loaded baskets, or loaded fascines.

The exact cost of this work cannot be accurately estimated, as, to the best of my knowledge, this method of protection has never been used on any of our public improvements. From the best evidence that I can obtain, I should think that a single long hurdle, 3 feet wide and 200 feet long, would cost about $36. This would make this protection cost about $12 per running foot, or $242,000 for four miles, or a little more than $60,000 per mile. Allowing liberally for contingencies we may safely estimate its limit of cost at $70,000 per mile. It should be borne in mind that no allowance is made for levee-building, which I think should be done by the people benefited, as other levees are.

There are many places needing protection where the depth of water is not as excessive as it is at Vicksburg, and where this method of protection would cost greatly less, but I have estimated for this particular case, because there the danger is pressing and must be met at once by some plan that is not so very expensive as to prevent its adoption. I do not propose this plan as a certainty, but only as one that I think demands a trial; and as something, no matter what, is imperatively called for to prevent the utter destruction of the finest harbor on the Mississippi, I offer it as probably the cheapest, and as one that certainly promises well.

The necessity of protecting the banks of the Mississippi in some way, I consider to be almost a vital one, especially since the rapid absorption of our available public lands will soon be attracting a heavy emigration to the richest soil within our national domain.

Hitherto towns, plantations, and levees have been swept away, and the enormous levee-taxes have kept down property at a low figure. In the interest of levees alone bank-protection is a necessity. Every time a levee is undermined a large tract of cultivated land is abandoned, and a much higher and more expensive levee is built in rear.

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New levees are always more costly than the old ones, because the land falls as you recede from the river, and, starting on lower ground, you have more to build to reach a given height. It is well known that when the Mississippi overflows its banks its heaviest deposits are made near the shore, and that the natural bank is higher there than elsewhere. This action is constantly taking place, no matter how much the channel shifts about; but after levees are built it is necessarily entirely stopped, and then when the river moves it is prevented from raising the surface behind the levee, and, consequently, when the old levee becomes endangered, and a new one becomes necessary, it must be built on ground that is as much lower than the site of the old levee as is due to the slope from the bank of the natural river. This slope averages 6 inches per mile, though it is often much more, and as the slope from the old river-bank, which may have been several miles off, remains unchanged, every withdrawal of the levee-line is at the expense of additional earth-work. The magnitude of this evil may be inferred from the statement that in some places the river has moved two miles within twenty years. Another important consideration is that, if the permanence of a levee were guaranteed, it would be possible to increase its height yearly, without excessive taxation, until it was absolutely secure from the highest possible floods. At present the resources of the country are often inadequate to raise a levee more than one or two feet above flood-line, and, consequently, they are in annual dread of crevasses. The levees on the Po, the Vistula, and the Lower Rhine are as high as any on the Mississippi, but they never require removal, and, therefore, have been made secure, and crevasses are unknown.

As an additional evidence of the importance of the proposed improvement, or something else to answer the same purpose, I would refer to the discussion by Major H. L. Abbott, Corps of Engineers, of the project for building a railroad-levee from opposite Memphis to Saint Louis. It is printed on pp. 468–473 in your annual report for 1868. It will be seen that he recommends that this grand levee, 17½ feet in average height, should be retired from the river-bank at least a mile and a half wherever it approaches one of the great bends. The area thus abandoned to the river (including the northeastern portion of the Saint Francis Basin, which is outside of the railroad-line, and where size is not stated) is 1,500 square miles. If a system of protection limited, if necessary, to the bends were put in practice, a large portion of this could be saved, and the levee could be built on higher ground, with a reasonable certainty of permanence.

Besides the destruction of old levees, it is a common occurrence for towns to be gradually washed away, of which Napoleon and Providence are two marked cases. The instances of the entire destruction of plantations are too numerous to mention, the channel having in some places, notably at Walnut Bend, moved two miles in a decade. But the greatest benefit that would accrue to the river from a successful protection of its banks would come from the prevention of cut-offs. A "cut-off" is the cutting off of a bend of the river by the formation of a channel through the neck of a long peninsula. The temporary diminution of distance by a cut-off is always accompanied by a great increase in the velocity of the current above and below the cut-off, on account of the increase of the surface-slope. The testimony of all river-men is unanimous that this diminution of length is but temporary, and that the increased current deepens all bends in the vicinity until the lost regimen of the river is restored. The wash of the banks, which at many places is now excessive, would everywhere be moderate and easily controllable,

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were it not for the sudden and violent changes of regimen caused by cut-offs. If we limit our work to the prevention of such disturbing causes alone, we will greatly benefit the whole alluvial region. It is easy to obtain testimony to corroborate these statements, but I will limit myself to quoting from Major Suter's report, in order to show the effect of cut-offs on the peninsula opposite Vicksburg.

Speaking of the great increase in the rate of abrasion since 1865, he says:

> There is no doubt in my mind that the formation of these two great cut-offs, Palmyra (1867) and Terrapin Neck, (1866,) was the cause of the very marked results visible since 1865. Their combined effect was to shorten the river some thirty miles, with proportionate increase in the water-slope. The efforts of the river to regain its lost regimen are made evident by the rapid cutting going on in all the bends for some distance above and below Vicksburg. It is only in this manner that the river can regain its original length and slope.

The incidental advantages of the protection of the banks of the Mississippi may be briefly enumerated. The great cause of snags, the caving in of acres at a time, would be entirely stopped, and the few snags brought in from tributaries could easily be taken out by the snag-fleet. Were the system extended up all tributaries, there would ultimately be no snags to be removed. The river now is overburdened with sediment in solution, not that the water always contains its theoretical maximum, but that it contains so much that it is constantly dropping it on bars when its velocity is checked. A large amount of sediment is due to caving banks. Were this stopped, the river-current could more readily carry what it obtains from tributaries, besides being enabled to take up more from its own bars, and its low-water channel would be permanently deepened. It would never again be necessary to build new levees, and the old ones could be raised above all possible floods. Permanent landing-places could be established, and substantial towns, with all the improvements of modern civilization, would replace the temporary villages now so common. Increased facilities for commerce, and diminished taxes for levee purposes, would stimulate production, and, with the increased healthfulness that would follow the prevention of overflows, there would be a permanent increase in population and in wealth, and the valley of the Mississippi would at last fulfill the constant prediction of those who know its inexhaustible capabilities, and become the garden of America.

Whether the means which I recommend are adequate to the end proposed can only be determined by actual trial, and, therefore, I would recommend that this trial be made at Vicksburg, or at some similar place, where a cut-off is threatened. Even should the plan proposed be a failure, it would probably result in securing information that would make the future solution of this important problem comparatively easy, and thus aid in protecting and preserving the richest valley on the face of the globe.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

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K 6.

EVANSVILLE BRIDGE.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 16, 1872.

SIR: I beg leave to acknowledge the receipt of a communication from the chairman of the Committee on Commerce, United States Senate, inclosing Senate bill 539, authorizing "the construction of a railroad-bridge across the Ohio River, at or near Evansville, in the State of Indiana," and requesting information, together with recommendation or suggestion in relation to the matter.

In accordance with the requirements of section 5 of the act approved July 11, 1870, making appropriations for the improvement of rivers and harbors, (see Statutes at Large, vol. 16, p. 227,) a board of engineers was constituted to report upon certain bridges then "erected or in process of erection" across the Ohio River. This report has been made, and may be found printed in Ex. Doc. 1, part 2, House of Representatives, Forty-second Congress, second session. I would respectfully suggest that the attention of the Committee on Commerce be invited to this report, and the recommendation contained therein, in regard to the conditions that should be required of corporations or companies who may be authorized to construct bridges across the Ohio River, (see pages 61 and 397 to 457 of the above-named document.) The board in the preliminary report of February 7, 1871, submitted a project of a general law applicable to bridges over the Ohio River, together with explanatory remarks. (See page 455.)

The provisions and requirements set forth in the project of the law submitted by the board are applicable to the bridge now proposed to be built at Evansville. I have, therefore, to recommend that the bill (S. 539) be amended by striking out all after the words, "*Provided*, That said bridge," on lines 13 and 14, and adding the following:

And that every bridge hereafter erected across the Ohio River, above the mouth of the Big Sandy, shall have at least one span of a height of not less than 90 feet above low water, and of not less than 40 feet above local highest water, measured to the lowest part of the span; that every bridge hereafter erected across the Ohio River, below the mouth of the Big Sandy, shall have at least one span of a height of not less than 100 feet above low water, and of not less than 40 feet above highest water, measured to the lowest part of the span; that this high span shall give a clear opening of at least 400 feet between the piers, measured at right angles to the current at every stage, and that it shall be placed over that portion of the river used by boats during ordinary stages of the water: *Provided*, That in case this high span is not over the low-water channel, suitable arrangements be made elsewhere to permit the passage of single boats under the bridge at low water; that all bridges over the Ohio River below the Covington and Cincinnati suspension-bridge shall have, in addition to the high span prescribed above, a pivot-draw giving two clear openings of 160 feet each, measured at right angles to the current at the average stage of water in the river, and located in a part of the bridge that can be safely and conveniently reached at that stage; and that said draw shall be opened promptly, upon reasonable signal, for the passage of boats, whose construction shall not be such as to admit of their passage under the permanent spans of said bridge, except when trains are passing over the same.

SEC. 2. *And be it further enacted*, That the piers of the high span and the piers of the draw shall be built parallel with the current at that stage of the river which is most important for navigation, and that no ripraps or other outside protection for imperfect foundations will be permitted in the channel-way of the high span or of the draw-openings.

SEC. 3. *And be it further enacted*, That any person, company, or corporation, authorized to construct a bridge across the Ohio River by the States upon whose territory said bridge will abut, shall submit to the Secretary of War, for his examination, a design of the bridge and piers and a map of the location, giving for the space of at least one

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mile above and one mile below the proposed location the topography of the banks of the river, the shore-lines at high and low water, the direction of the current at all stages, and the soundings accurately showing the bed of the stream, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject by the Secretary of War; and if the Secretary of War is satisfied that the provisions of the law have been complied with in regard to location, the building of the piers may be at once commenced; but if it shall appear that the conditions prescribed by this act cannot be complied with at the location where it is desired to construct the bridge, the Secretary of War shall detail a board, composed of three experienced officers of the Corps of Engineers, to examine the case, and may, on their recommendation, authorize such modifications in the requirements of this act as will permit the construction of the bridge: *Provided*, That the free navigation of the river be not materially injured thereby.

SEC. 4. *And be it further enacted*, That all parties owning or operating bridges over the Ohio River shall maintain, at their own expense, from sunset to sunrise throughout the year, such lights on their bridges as may be required by the Light-House Board for the security of navigation.

SEC. 5. *And be it further enacted*, That any bridge constructed under this act, and according to its limitations, shall be a lawful structure, and shall be recognized and known as a post-route, upon which, also, no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the navigation of said river created by the construction of any bridge, under this act, the cause or question arising may be tried before the district court of the United States of any State in which any portion of said obstruction or bridge touches.

SEC. 6. *And be it further enacted*, That the right to alter or amend this act so as to prevent or remove all material obstructions to the navigation of said river by the construction of bridges is hereby expressly reserved.

SEC. 7. *And be it further enacted*, That joint resolution No. 10, approved April 7, 1869, authorizing the construction of a bridge over the Ohio River at Paducah, be, and the same hereby is, repealed.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

K 7.

PARKERSBURG BRIDGE.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 29, 1872.

SIR: In reply to the communication of the Committee on Commerce, United States Senate, of January 19, requesting information and recommendations or suggestions in relation to the "petition of citizens of Allegheny County, Pennsylvania, for re-imbursement of expenditures to prevent the damaging effects of the Parkersburgh bridge upon the navigation of the Ohio River," I beg leave to state that the full report of the board of engineers upon the bridge across the Ohio River may be found printed in appendix to report of the Chief of Engineers, Executive Document 1, part 2, House of Representatives, Forty-second Congress, second session. The portion relating specifically to the Parkersburgh bridge, and to the question submitted, is found on pages 411 to 414, and on page 430.

It appears that a modification was made in the plan of the bridge during its construction to meet the wishes of the coal-boat interest, which increased the cost of the bridge about $60,000. An arrange-

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ment was made between the railroad company and the petitioners, by which this sum was to be equally divided between them. The petitioners now ask the United States to re-imburse them to the amount thus expended.

The question reduces itself to this: Is the United States liable for the increased cost due to a modification of plan which was necessary in order to protect the navigation interest, while, at the same time, the construction of the bridge, according to the original plan, would have been strictly within the requirements of the act authorizing the building of bridges over the Ohio River, approved July 14, 1862?

This question is somewhat analogous to the one raised during the construction of the Cincinnati bridge, and as the payment of the increased cost due to modification in plan of the last-named bridge has been provided for by legislation, (see section 5 of the act making appropriations for the Post-Office Department, Vol. XVI, Statutes at Large, page 572–573,) it would seem proper that the question of liability of the United States in the construction of the Parkersburgh bridge and the payment of damages should be determined and settled in the same manner as therein provided for the Newport and Cincinnati bridge.

The letter of the chairman of the Committee on Commerce and the petition are herewith returned.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

APPENDIX L.

ANNUAL REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 1, 1872.

GENERAL: I have the honor to transmit the following report of the operations at the improvement of the Falls of the Ohio River and Louisville Canal for the fiscal year ending June 30, 1872.

On the 22d of July, 1871, I opened the bids for excavating the ledge of rocks inside of the apron-dam at the head of the canal, and completing dam across the river, at the crest of the falls of the river, referred to in my last annual report. I received only two bids, as shown on Abstract A herewith annexed. I considered both of the bids exorbitant, and therefore recommended that both be rejected. This was approved, and I was authorized to re-advertise the work, and in the mean time to prosecute it with hired labor and the purchase of material in open market. I advertised again on the 5th of August, 1871, for bids for this work, and, in accordance with the authority granted me, limited the bidding to fourteen days. I accordingly opened the bids on the 19th of August, 1871. There were only two bidders, as shown by Abstract B, herewith annexed. I considered both of these bids exorbitant, and recommended the rejection of both. This was approved, and during the remainder of the season I prosecuted the work with hired help. The season was an unusually favorable low-water season, and,

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consequently, the maximum force that could be worked was employed. The dam was completed from the Indiana shore to the sluice in the Indiana Chute. About one-half of the dam from the Kentucky side to the sluice in the Indiana Chute was completed, and the foundation-timbers were gotten in for about two-thirds of the distance. The apron-dam was raised one foot, this having become necessary in consequence of the increased draught of vessels navigating the canal. About 2,600 cubic yards of the rock-ledge, inside of the apron-dam, were blasted, and about 1,200 cubic yards of it placed in the dam across the river.

In the mean time, on the 20th of July, 1871, the water was drawn from the canal, and about the beginning of September, 1871, the work was prosecuted with great vigor along the whole line. This continued until the night of the 22d of November, 1871, when the rise in the river compelled the stoppage of the work. All of the contractors had done as well as they could under the circumstances, and by your authority the time of those who had not completed their contracts was extended through this season.

In addition to the work on the dam and rock-ledge, as above specified, the following was accomplished, viz:

Messrs. Mackenzie & Gordon completed their work at the enlargement of the entrance to the canal. This entrance is now 110 feet wide instead of 64 feet, and is lined on both sides with substantial side-walls.

Messrs. Byrne & Mackenzie completed their contract for carrying up the new side walls on part 1 to within about 5 feet of their ultimate height, and removing the abrupt turn under the railroad-bridge by excavating on a gentle curve, connecting the two portions of the main prism of the canal above and below the railroad-bridge.

Mr. M. D. Lord completed about two-thirds of his work on making the passage for boats to get through the draw of the railroad-bridge at high stages of the river, and thus enabling them to pass the bridge without lowering their smoke-stacks.

Messrs. Hugh McGlincey & Co. completed the widening of Section No. 2 of the canal to 86 feet, but did not finish the passing-place below the Elm-Tree Garden bridge, but will undoubtedly finish it this season.

Mr. J. C. Dennis furnished all the stone for building the new side-walls on part 2 to within about 5 feet of their ultimate height, and built as much of these walls as the work of Hugh McGlincey & Co. would permit.

Messrs. Samuel Black & Co. completed their work of widening Sections Nos. 3 and 4 of the canal to 86 feet.

Mr. Michael Gleason completed his work for earth and rock excavation in the basin which joins the new branch to the old canal.

Messrs. H. T. Cook & Co. completed the new locks and lock-gates and their machinery, and the excavation of the new branch to the same.

Messrs. Boyle & Roach completed the new side-walls on parts 4 and 5 to within about 5 feet of their ultimate height, and delivered most of the stone for part 3. This same firm almost nearly completed the excavation of the rock-ledge at the outlet of the new locks, and built about 100 feet of the guide-wall below the new locks, and delivered nearly all of the stone required for the whole wall.

Messrs. Ferrill & Clark carried the dam at the head of Sand Island from the Indiana shore well into the island.

In fine, on the night of the 22d of November, 1871, the work was in such a condition that the largest vessels navigating the Ohio River could be passed through as soon as the directors could dredge the mud which had accumulated in ten years from back-water, out of the new locks.

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A few moments after midnight on the morning of November 23, 1871, the water was let into the canal, and at about 8 o'clock on the same morning, and when the water stood at about the height of 19 feet against the guard-gates of the new locks, it was observed that the miter-sills of these locks were all giving way. The guard-gates at the head of the canal were closed as quickly as possible, and the water again drawn off. In accordance with your instructions, I made a full report of the incidents connected with the accident, the causes thereof, and the step I took to repair the damage. This report is dated January 9, 1872.

There was not a moment to be lost. I therefore immediately cut off the new locks from the canal by means of a dam, thrown across the branch just above them. This was constructed in three days and nights. The water was then again let into the canal, and the commerce of the river was thus hindered no longer than often happens by an accident to a vessel in it, or not so much hindered as it frequently is by the mud after a rise in the river. I worked night and day whenever the weather would permit, and had the good fortune to accomplish the repair of the damage on the 26th of December, 1871. The directors cleaned the mud from the new locks as rapidly as the machinery at their disposal and the weather would permit, and finally, on the 26th of February, 1872, the largest class of boats commenced passing through, and have been passing through ever since, and the Louisville and Portland Canal was thus practically enlarged.

Feeling certain that a further appropriation of $300,000 would be made by Congress at its last session for continuing the work on the canal, I asked for and received authority to advertise for bids for the work to be done during the present season. I opened the bids on the 17th of June, 1872. The abstract of these bids is herewith annexed, marked C. The contracts were all awarded by your direction to Messrs. Sheehan & Loler, the lowest bidders. By your letter of the 19th of June, I was officially informed that $300,000 had been appropriated by the act approved June 10, 1872, for continuing the work on the canal, and then entered into contract with the above firm for completing the side-walls along the whole length of the canal and the new side-walls on the south side of the entrance to same, and for grading the banks along the whole line at those points where the old side-walls and banks were disturbed by the work of enlargement.

By your letter of the 19th of June, 1872, I was directed to give official notice to the president and directors of the canal company of the provisions of the last clause of the item making appropriation for that work, relating to tolls.

In accordance with this direction I addressed a letter to the president and board of directors of the canal, of which the following is a copy, viz:

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, June 25, 1872.

GENTLEMEN: I have received an official communication from Brigadier-General A. A. Humphreys, Chief of the Corps of Engineers, United States Army, dated June 19, 1872, which concludes with the following paragraph, viz:

"You will also please give official notice to the president and directors of the canal company of the provisions of the last clause of the item making appropriation for that work, relating to tolls."

In accordance with this instruction, I hereby officially notify you that the item above referred to is as follows:

"For the continuing the work on the canal at the Falls of the Ohio River, $300,000. And the Secretary of War is hereby directed to report to Congress, at its next session, or sooner, if practicable, the condition of said canal and the provisions necessary to relieve the same from incumbrance, with a view to such legislation as will render the

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same free to commerce at the earliest practicable period, *subject only to such tolls as may be necessary for the superintendence and repair thereof, which shall not after the passage of this act exceed 5 cents per ton.*"

I have underlined the last clause of the item to which my instructions refer.

Very respectfully, &c.,

G. WEITZEL,
Major of Engineers.

The PRESIDENT AND DIRECTORS
of the Louisville and Portland Canal, Louisville, Kentucky.

In reply I received an answer, of which the following is a copy, viz:

OFFICE OF LOUISVILLE AND PORTLAND CANAL COMPANY,
Louisville, June 27, 1872.

SIR: I am instructed by the board of directors of this company to acknowledge the receipt of your letter of the 25th instant, and to say the company will do nothing that may be construed into an acknowledgment that the Government can fix the rate of tolls for the use of the canal until the joint resolution of the Kentucky legislature, approved March, 1872, shall have been complied with by the United States.

The company is further advised that a permission to expend the $300,000 in continuing the work on the canal, as appropriated in the late act of Congress, might be regarded as an acknowledgment of a right in the Government to fix the tolls at 5 cents per ton. Justice to the creditors of the company and duty to the State compel the company to decline the appropriation and refuse the use of the canal for its expenditure.

I am, respectfully, your obedient servant,

J. F. SPEED,
President Louisville and Portland Canal Company.

General G. WEITZEL,
Louisville, Kentucky.

I then addressed them a letter, of which the following is a copy:

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, June 29, 1872.

GENTLEMEN: I have the honor to acknowledge the receipt of your communication of the 27th instant.

Do I understand that you object to any work on the canal, even if it does not involve the drawing off of the water, such, for instance, as delivering stone for the new side-walls, constructing these walls, and grading the banks?

I respectfully request a reply to-day, in order that I may advise the contractors on the work what to do.

I am, gentlemen, your obedient servant,

G. WEITZEL,
Major of Engineers.

The PRESIDENT AND BOARD OF DIRECTORS
of the Louisville and Portland Canal, Louisville, Kentucky.

To this I received a reply, of which the following is a copy:

OFFICE OF THE LOUISVILLE AND PORTLAND CANAL COMPANY,
Louisville, June 29, 1872.

SIR: Your letter of to-day is received. I am instructed to say that the whole appropriation is declined, and no part of it can be expended on any of the property of the company.

The directors are advised that any assent from them to the use of the appropriation upon the canal might be construed into an acceptance of the act of Congress, and such acceptance would be a repudiation of the debt of the company which has been incurred under congressional legislation.

I am, very respectfully, your obedient servant,

J. F. SPEED, *President.*

General G. WEITZEL.

I fear that the position taken by the directors of the canal will cause delay and additional expense, and may make it necessary to revise my estimates, and I will, therefore, make a special report on the matter as soon as it is settled. If no delay should be occasioned by this matter, and the season is favorable, I believe that the work now under contract will all be completed.

There would then only remain to complete the work the completion of the dam and rock excavation at the head of the canal, and raising

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the outer protection wall of the canal, next to the river, and above the railroad-bridge about 6 feet.

The necessity of raising this wall never suggested itself to me until during the high water of last spring, and has heretofore not been estimated for nor considered a part of my plan. The earth-bank of the canal at this point is only about 18 feet high. It is protected against encroachment from the river by a rubble-wall about 3,800 feet long. But at certain high stages of the river like that of last spring the water from the canal flows from the canal sideways into the river and wears away the bank. To arrest this injurious action it is proposed to raise said wall about 6 feet. I consider this absolutely necessary, though it will cost about $50,000 additional.

In order to complete this work it will, therefore, require an additional appropriation of $200,000, which I respectfully request may be made. A failure to appropriate the whole amount will still further increase the cost of the work, by reason of the increase in contingent expenses when a work is prolonged through several seasons.

This work is located in the third collection district of Kentucky. The nearest port of entry is Louisville, Kentucky. The amount of revenue collected at this port of entry during the fiscal year ending June 30, 1872, was $122,296.14.

The commerce and navigation of the Mississippi River and all of its branches would be benefited by the completion of this work.

Abstract D (herewith annexed) shows the names of the persons to whom contracts have been awarded.

That portion of this report which narrates the progress of the work shows fully the steps I have taken to prosecute the work.

The amount of cash received for this work during the fiscal year ending June 30, 1872, is $420,000. The amount expended during the same period was $519,152.88.

The amount of appropriation available June 30, 1872, was $46,033.66. The amount required for the fiscal year ending June 30, 1874, is $200,000.

I do not propose to make any further alterations in the plans heretofore reported.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

A.—*Abstract of bids received by Major G. Weitzel, Corps of Engineers, for excavating the ledge of rocks inside of the apron-dam at the head of the Louisville and Portland Canal, and completing the dam across the river. Letting, July 22, 1871.*

Name of bidders.	Timber and plank, 574,300 feet, board measure.	Riprap, or apron slope, 5,000 cubic yards.	Excavation of rock ledge, 4,500 cubic yards.	Total.
H. T. Cook & Co	$95 00	$5 00	$12 00	$133,549 00
Samuel Black & Co	90 00	5 50	11 50	130,928 00

Respectfully submitted.

G. WEITZEL,
Major of Engineers.

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B.—*Abstract of bids received by Major G. Weitzel, Corps of Engineers, for excavating the ledge of rocks inside of the apron-dam at the head of the Louisville and Portland Canal, and completing the dam across the river. Letting, August* 19, 1871.

Name of bidders.	Completion of dam, 363,300 feet, board measure.	Riprap slope, 5,000 cubic yards.	Excavation of rock ledge, 4,500 cubic yards.	Total.	Excavation of rock ledge alone, 4,500 cubic yards.	Total.
J. B. Thompson	$70 00	$3 00	$9 00	$80, 931 00	$13 00	$58, 500 00
H. T. Cook & Co	90 00	3 80	9 40	93, 997 00	10 90	49, 050 00

Respectfully submitted.

G. WEITZEL,
Major of Engineers.

C.—*Abstract of bids received by Major G. Weitzel, Corps of Engineers, for the construction and completion of retaining-walls in Louisville and Portland Canal, and for grading slopes of canal bank. Letting, June* 17, 1872.

PART ABOVE UPPER-GUARD GATES.

Name of bidders.	Earth excavation, 3,000 cubic yards.	Masonry, 1,950 cubic yards.	Total.
Sheehan & Loler	$0 65	$11 10	$23, 595 00
Boyle & Roach	1 50	9 84	23, 688 00
Byrne & Mackenzie	1 00	13 60	29, 520 00
Michael Haviland*	1 00	11 25	24, 937 50

*Informal. No guarantee attached.

PART 1.

Name of bidders.	Earth excavation, 1,000 cubic yards.	Masonry, 3,100 cubic yards.	Total.
Samuel Black & Co	$0 49	$14 00	$43, 890 00
Sheehan & Loler	40	10 25	32, 175 00
J. C. Dennis	1 00	14 50	45, 950 00
Boyle & Roach	40	11 80	36, 980 00
Byrne & Mackenzie	45	10 25	32, 225 00

PART 2.

Name of bidders.	Earth excavation, 10,500 cubic yards.	Removing old wall, 250 cubic yards.	Masonry, 3,050 cubic yards.	Total.
Samuel Black & Co	$0 49	$1 00	$11 00	$38, 945 00
Sheehan & Loler	40	1 00	10 25	35, 712 50
J. C. Dennis	1 00	1 25	14 50	55, 037 50
Boyle & Roach	42	25	11 25	38, 785 00
Byrne & Mackenzie*	55	.....	11 25	40, 087 50

*Informal. No bid for removing old wall.

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PART 3.

Name of bidders.	Earth excavation, 20,900 cubic yards.	Masonry, 4,100 cubic yards.	Total.
Samuel Black & Co	$0 49	$11 00	$55,341 00
Sheehan & Loler	40	10 25	50,585 00
J. C. Dennis	1 00	14 50	80,350 00
Boyle & Roach	48	11 50	57,182 00

PART 4.

Name of bidder.	Earth excavation, 4,500 cubic yards.	Masonry, 1,200 cubic yards.	Total.
Samuel Black & Co	$0 49	$11 00	$15,405 00
Sheehan & Loler	40	10 25	14,100 00
J. C. Dennis	1 00	14 50	21,900 00
Boyle & Roach	48	11 50	15,960 00

PART 5.

Names of bidder.	Earth excavation, 5,100 cubic yards.	Masonry, 1,350 cubic yards.	Total.
Samuel Black & Co	$0 49	$11 50	$18,024 00
Sheehan & Loler	40	10 25	15,877 50
J. C. Dennis	1 00	14 50	24,675 00
Boyle & Roach	42	11 75	18,004 50

Respectfully submitted,

G. WEITZEL,
Major of Engineers.

D.—*Abstract of the names of persons to whom contracts have been awarded.*

Name.	Residence.	Nature of work.
Sheehan & Loler	St. Louis, Mo.	Constructing and completing new retaining-walls in Louisville and Portland Canal.

L 2.

FALLS OF THE OHIO RIVER AND LOUISVILLE CANAL.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, September 20, 1872.

GENERAL: Referring to my annual report of operations at the improvement of the Falls of the Ohio River and Louisville Canal, for the fiscal year ending June 30, 1872, I now respectfully desire to add that

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the correspondence between the president and board of directors of the Louisville and Portland Canal and myself, the beginning of which was mentioned in the above report, was continued. The following are copies of the various letters which passed between us:

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 1, 1872.

GENTLEMEN: I have received your communication of the 29th ultimo, and have carefully considered it, as well as yours of the 27th ultimo.

I agree with you fully that Congress has not yet the right to fix the rate of tolls on the canal, and at first believed that the last clause of the paragraph added to the item in the river and harbor bill, approved June 10, 1872, (which appropriates $300,000 for continuing the work on the canal,) which attempts to fix the rate of tolls at 5 cents per ton had been added and passed solely by the aid of influences that unfortunately sometimes have great power in the hurry of the closing hours of Congress, and especially when such a session just precedes a presidential election. But since the receipt of your last communication, I have heard from the very best authority that the friends of the work voted for the bill as it stood, knowing that Congress had yet no right to fix the rate of tolls, in order to prevent the loss of the whole bill and to indicate to the people of the West that they proposed soon to do that act of justice which they should have done years ago, and which your board has repeatedly urged Congress to do ever since 1855, namely, to comply with the terms of your charter and make the canal free.

I further believe that you are acting wisely and properly in continuing to exact the same rate of tolls as heretofore; for if you did not the whole work might be lost to the Government, by foreclosure of the mortgage held by bondholders.

But I feel convinced that your fears that if you assented to the expenditure of the appropriation of $300,000 just made, it might be construed into an acceptance of the act of Congress which fixed the rate of tolls at 5 cents, are not well grounded. And I will say here that as the representative of the Government, I will do all in my power to cause it to make good any damage that might be done you or any of the creditors of the company at the next session of Congress. But if you will continue to collect the tolls as you do now, no damage can result.

But if you attempt to stop this work now, you will cause great damage to the whole country by increasing the cost of the work and making the Government liable for damages to contractors, and you will be inflicting a great harm on the whole commerce of the western rivers by delaying the period when the canal will become free. As the representative of the people, I consider it my duty to guard against any such consequences, and I will therefore carry on the work until I am ordered by my superiors to stop; and I request that you do not interfere until I can hear from them.

There is no person who has a higher regard for the gentleman and lawyer who acts as your adviser in this matter, but I cannot understand how he can see any proviso affecting the appropriation. I have sent you an exact copy of the item with the annexed clause, and the word "provided" does not occur in it. Nor can I see how you can now attempt to stop the Government while it is engaged and has been during the last four years with the same degree of rapidity as on other works, in taking the first step towards complying with your charter, namely, enlarging the canal. Especially since you have never heretofore made any objections to the work, but on the contrary have displayed the utmost courtesy and zeal in assisting me in its prosecution, and have during two seasons closed it to enable me to do the work as economically and expeditiously as possible.

In conclusion, I respectfully ask a definite reply to my letter of June 12, 1872, requesting you to close the old canal four weeks and the new locks seven weeks. This is to enable the contractors under the appropriation made last year to complete their work.

I am, gentlemen, your obedient servant,

G. WEITZEL,
Major of Engineers.

To the PRESIDENT AND BOARD OF DIRECTORS
of the Louisville and Portland Canal, Louisville, Kentucky.

OFFICE OF THE LOUISVILLE AND PORTLAND CANAL COMPANY,
Louisville, July 3, 1872.

SIR: I am instructed by the board of directors of this company to acknowledge the receipt of your letter of the 1st instant, and to reply that you are right in saying that the board have ever been anxious that the Government of the United States should take charge of and manage the canal. For years the duties of the board have been arduous, responsible, without profit to themselves, and thankless. Under the legislation of the State and Federal Governments they pledged the revenues of the com-

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pany to enlarge the canal to meet the pressing wants of commerce. To keep up the credit of the company, and the canal open to commerce, they have repeatedly been compelled to pledge their individual credit for large sums. They have ever acted with the purpose of hastening the day when they may be relieved of their trust, and the canal be made free, but always with a proper reference to the plain dictates of common honesty. While they have ever acknowledged their obligations to the public, they have never forgotten their duties to creditors. Justice to creditors is the first duty to the public. Any dereliction in this regard would and should meet with prompt and merited censure.

This company would cheerfully render you all the facilities they have heretofore done, if such conduct could not be construed into an acknowledgment that the Government of the United States can fix the rates of toll for the use of the canal. Such an acknowledgment would amount to nothing more nor less than a repudiation of the debt of the company, since 5 cents a ton, the sum fixed in the act of Congress, would not even pay the expenses of opening and shutting the locks. What the friends of the appropriation may have intended by their votes in Congress can only be known from the context of the act itself. By the act $300,000 are appropriated to continue the work on the canal, and the tolls are fixed at 5 cents per ton after its passage. The act must be taken as a whole. This company cannot presume to cut it into two parts, taking that which is for its benefit and rejecting the other. Though the word "provided" be not in the act, it means just the same as if it were there.

This company does not see how it can take the benefit of the act and not pay the price fixed therein for that benefit, which is a reduction of tolls to 5 cents per ton. That would be simply repudiation. Nor does the company see how a mere protest against the work being done would relieve it. If the company takes the benefit willingly or unwillingly it may have to pay the price involved in a reduction of tolls.

Were this a matter within your discretion and that of the company, it is needless to say it could be easily adjusted. But an act of Congress is above the reach and power of both, and this company must decide, knowing that the act of Congress cannot be modified by any department of the Government. Hence the company regards it an imperative duty to decline the appropriation and every part of it, and refuse the use of the canal for the expenditure of any part of it.

If there is any unused remainder of previous appropriations the company would not object to its use. But no part of the $300,000 appropriated in the act of the 10th of June, 1872, can be expended on the canal either upon old contracts or new ones.

Very respectfully, your obedient servant,

J. F. SPEED,
President.

General G. WEITZEL.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 5, 1872.

GENTLEMEN: I have the honor to acknowledge the receipt of your communication of the 3d instant, and have transmitted a copy of it to the Government.

I have a balance of over $80,000 from last year's appropriation, which was pledged to complete last year's contracts. To enable this to be expended, I request the canal to be closed as expressed in my letter of June 12, 1872.

I of course do not presume to discuss legal questions through you with your adviser, but I cannot see how you can stop the Government in completing the enlargement when about three-fourths of the work is done. The Government had the right to enlarge the canal at any time, since all the private stock, except the five shares held by you, were purchased, and it is now exercising that right. I consider, also, that the clause making the appropriation of $300,000 for continuing the work is entirely separate from and independent of the clause in which occurs the passage relating to the reduction of tolls.

I am, gentlemen, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

The PRESIDENT AND BOARD OF DIRECTORS
of the Louisville and Portland Canal.

OFFICE OF THE LOUISVILLE AND PORTLAND CANAL COMPANY,
Louisville, July 8, 1872.

SIR: I am instructed to acknowledge the receipt of your letter of the 5th instant.

You take it for granted that the Louisville and Portland Canal belongs to the Government of the United States. In that you are mistaken. The Government is but a stockholder in a Kentucky corporation, and has only such rights as are conferred by the act of incorporation and its amendments. Those rights cannot be enlarged at the mere will of the Government. The State of Kentucky and the directors of the company have for thirty years been eager to have the Government take control of the

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canal; they are now eager that the Government shall do so. The State has carefully prescribed the terms upon which the canal must be surrendered. This company would be faithless to the State and to the creditors of the canal if control of the canal should be given up before those terms are complied with.

Your last letter satisfies this company of the propriety of its course in refusing the use of the canal for the expenditure of the appropriation in the last act of Congress. If a gentleman familiar as you are with the history of the canal can make such a mistake in regard to its ownership, boatmen using the canal would surely come to a like erroneous conclusion, and give all possible trouble. Duty to the State and justice to creditors require the directors to deny that the Government of the United States has any right to enlarge the canal except under and in obedience to the charter of the company. When appropriations have been made that could be used on the canal consistently with faith to the State and duty to creditors, this company has cheerfully permitted their use. Now an appropriation has been made, and in the act of making it, the Government assumes the right to fix tolls. This company is bound to deny the right and resist the assumption.

As was said in my previous communication, the company is willing that any unused balance of previous appropriations may be expended, and as the company will have to close the canal about the 1st of August to do some work on it, to remain closed from perhaps four to six weeks, such unused balance may be expended during that time. It must be distinctly understood, and by a writing to be preserved among the miniments of the company, that no part of the $300,000 appropriated in the last act of Congress is to be used.

Very respectfully, your obedient servant,

J. F. SPEED,
President.

General G. WEITZEL.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 9, 1872.

GENTLEMEN: I have received your communication of yesterday, and have carefully read over the copy of my communication of the 5th instant to you, and I do not understand how you deduce from it that I take it for granted that the Louisville and Portland Canal belongs to the Government of the United States.

From the latter part of the year 1867, when I first made myself acquainted with the history of the canal, I have continually insisted upon it in my official reports, in private conversation, and in my intercourse with you, both verbal and written, that the ownership and control of the canal by the Government is conditional upon its complying with the terms of the charter granted your company by the State of Kentucky, as amended from time to time.

At the time I commenced the work of enlargement of the canal in 1869, the joint resolution of the Kentucky legislature of last March had not passed, and the first step under the charter that the Government was compelled to take was to enlarge the canal; the second was to assume the debt; and the third, to make the canal free. The Government entered upon the execution of the first step in 1869, and has prosecuted that step since with the same rapidity that it has on all other works of like magnitude. Now, what I wished to express in my communication of the 5th instant is that I doubted if you could in any way stop the Government in completing that step.

The whole controversy narrows itself, in my opinion, to a solution of this question, and the other one, whether the $300,000 was appropriated upon the condition that the tolls shall be reduced to 5 cents per ton. You assert that it was appropriated upon this condition, and I maintain that it was not. Gentlemen who voted for it have informed me that I am right.

But as I have no power to decide these questions I have referred copies of all our correspondence to the Government for its action and instructions in the matter.

I am, gentlemen, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

The PRESIDENT AND BOARD OF DIRECTORS
of the Louisville and Portland Canal.

LOUISVILLE AND PORTLAND CANAL COMPANY,
Louisville, July 29, 1872.

SIR: In my last letter to you I said that this company would not object to the expenditure on the canal of any unused balances of previous appropriations, but that no part of the $300,000 appropriated in the last act of Congress could be used. I also advised you that the understanding must be distinct and in writing. You were also advised that the canal would be closed about the 1st of August, when that unused balance could be expended.

I am now instructed by the company to say that the water is now, and for some time

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will probably continue to be, so high that it would avail nothing to close the canal at that time, and it is impossible now to fix a time for closing it.

I am also instructed by the company to call your attention to the accompanying slip, which appeared in the Louisville Commercial of yesterday. The company does not know Messrs. Sheehan and Loler, said to be "contractors for completing the improvements of the canal under the last appropriation of Congress." If the gentlemen are contractors at all it must be with you, as the agent of the Government. This company must therefore rely on you to advise those gentlemen of their rights and responsibilities. The company cannot believe that the Government, or any officer of the Government, will seek to do indirectly that which cannot be done directly and by virtue of plain legal and moral right.

In view of the public pretension of right by the gentlemen calling themselves contractors for completing the improvements on the canal, it becomes the duty of this company to learn from you whether those gentlemen are acting under your authority, and, if so, whether they are to do more than expend the unused remainder of former appropriations.

I am, very respectfully, your obedient servant,

J. F. SPEED,
President Louisville and Portland Canal Company.

General G. WEITZEL.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, August 2, 1872.

GENTLEMEN: I have received your communication of the 29th ultimo. In reply, I have to say that in my letter to you of the 1st ultimo I informed you that I could not stop the work until I received instructions from my superior officers to do so. I expect instructions from them every day, and as soon as they are received will inform you. In the mean time I repeat the request contained in my letter of the 1st ultimo, that you do not interfere until I receive those instructions.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

The PRESIDENT AND BOARD OF DIRECTORS
of the Louisville and Portland Canal.

In the mean time, on the 1st of July, 1872, I requested that the United States district attorney at this place (Colonel G. C. Wharton) be ordered to act as my counsel in this matter, to prevent the directors from interfering with my work. This was done.

Through the good sense of this gentleman and that of the Hon. James Speed, the counsel for the directors, and their associate counsel, it was agreed, after a little preliminary legal skirmishing, to bring the case at once before a judge of the Supreme Court for decision. The case was tried before Associate Justice Miller, of the United States Supreme Court. He granted an injunction, preventing the directors from interfering with the work, but in effect decided that the directors alone, as yet, had the power of regulating the tolls.

This decision was satisfactory to all, and the work has been progressing uninterruptedly since.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

L 3.

LOUISVILLE AND PORTLAND CANAL.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, January 9, 1872.

GENERAL: In accordance with the directions contained in your letter of the 26th of December, 1871, I have the honor to report as follows

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concerning the causes of the accident to the miter-sills of the new locks of the Louisville and Portland Canal, referred to in my letter of December 6, 1871.

In order that the report may be perfectly understood, I transmit to you by express, to-day, seven sheets of drawings, showing the construction of the locks referred to. This is not the complete set. Three more sheets are wanting, showing the details of the lower lift-gates, the guard-gates at the head of the canal, and the machinery for operating, the gates. But the seven sheets now sent are all that is required for a full understanding of the subject.

An eighth sheet is transmitted, entitled "Plan and sections of the miter-sills of the guard and upper lift-gates of the new locks of the Louisville and Portland Canal." This sheet shows, on an enlarged scale, the original and the new construction of the miter-sills. These drawings show the construction of these locks so much in detail that I do not believe that any description, which I can give, will be necessary to a full understanding of the subject, and I will confine myself to merely saying that the new locks of the Louisville and Portland Canal consist of two chambers, with, of course, three lift-gates, and provided in their head-bay with a set of guard-gates. These guard-gates are intended to prevent the water from rushing through the locks in high stages of the river, and also to enable repairs to the lift-gates to be made in case of any damage.

The miter-sills of these four sets of gates were designed substantially alike in plan. In section the miter-sills of the guard-gates and the lower lift-gates are alike, and the sills of the upper and middle lift-gates are alike. The former resting upon the bottom of their respective chambers; the latter partially upon the lift-walls and partially upon the bottom of their respective chambers. The two upper sills rest upon slate-rock, and the two lower on limestone. They were built as designed, except in two respects, which were cheats on the part of the builders, discovered by the accident, but were not in the least degree the cause of it. They were as follows, viz:

The arches of the miter-sills of the guard-gates, and the lower lift-gates, were not abutted into the side-walls as they were designed, and the two stones *a*, *b*, (in plan,) and *a*, (in section,) of both these sills were only 16 inches thick, instead of 2 feet, and seemed to have been laid on rubble masonry 8 inches thick, to be flush with the top of the remainder of the sill.

In reconstructing these sills I abutted the arches into the side-walls, but could not replace the four stones, and therefore relaid them carefully.

To proceed with the cause of the accident. At about 7½ o'clock on the night of the 22d of November, 1871, the last rock was excavated which completed the widening of the prism of the canal. The excavation of the branch to the new locks and basin joining the branch with the old canal was completed, and the four sets of gates in the new locks were closed. There was no water in the canal, the water having been drawn off on the 20th of July previous, for my season's work. The water is drawn off by simply closing the guard-gates at the head of the canal, and opening the gates of the locks at the lower end of the same.

All had received due notice, by telegrams from above, that a rise in the river sufficient to open navigation would reach the canal at some time during the next morning, and that with the rise were coming a great many vessels of all descriptions, to go through the canal going down. During the whole working-season there were a large number of

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vessels lying before the canal waiting to go up, and these were ready to go up through the canal as soon as the rise reached here.

It was for this reason that the directors of the canal took charge of it immediately, and at 12 o'clock at night commenced letting in the water by opening the wickets of the guard-gates at the head of the canal. At 8 o'clock next morning (23d of November) the water in the canal stood on a level with the water in the river, and the guard-gates at the head of the canal were then thrown open and it opened to commerce. The river continued to rise steadily, and, as accurately as I can learn, when the water stood against the guard-gates at the head of the new locks about 9 feet higher than the top of its miter sill, they were seen suddenly to rise at the toe-posts, and the water immediately after to violently bubble up from under them. It seems that then some one who is not known, but is supposed to have been one of the lock-tenders at the old locks, opened one of the wickets in each of the upper and middle lift-gates, to give an outlet to the water which came from under the bottom and through the leakage of these guard-gates, and this then filled up the lower chamber and brought a similar pressure upon the lower lift-gates, which acted precisely as the guard-gates. The water filled up next against the middle lift-gates with the same result, and finally against the upper lift-gate with like result. This last miter-sill gave way at about 2 o'clock in the afternoon. In the mean time there were several vessels passing through the canal, and the water could not be drawn off until they had passed safely through. The guard-gates at the head of the canal were then again closed and the water drawn off. It required until some time during the night to do this, and on the next morning I found the following to be the condition of the sills and gates:

GUARD-GATES AT HEAD OF LOCKS.

The 10 by 10 timber which was let into a rebate on the front of each sill. and bolted to it for the purpose of forming an elastic cushion for. and water-tight point with, the lower bar of the gates, was raised about 1½ inches at the miter, but was held firmly by the side-walls. I have shown this on the unnumbered sheet above referred to, under the head of "Old condition," on the elevation designated "Front elevation of miter-sills," by the red lines. Undoubtedly these timbers had been raised higher than 1½ inches at the miter-posts, but settled down with the gates when the water was drawn off. Every stone in the whole sill. except the two stones on each side nearest the side-walls, were loosened from their beds, and all of the stones, except the arch-stones, lay with either their front or rear edge a little raised, as shown by the red lines on section on A B, "Old condition." The two stones above referred to, *a b* on plan and *a* on section, were lifted completely out of their beds, as shown by the red lines on the same section. Nearly all of the stones to which the timber-cushion was bolted had pieces broken out of their front portions, under the rebate, by these bolts. The gates were considerably out of miter; that is, the bearing-surfaces of the miter-posts did not coincide.

UPPER LIFT-GATES.

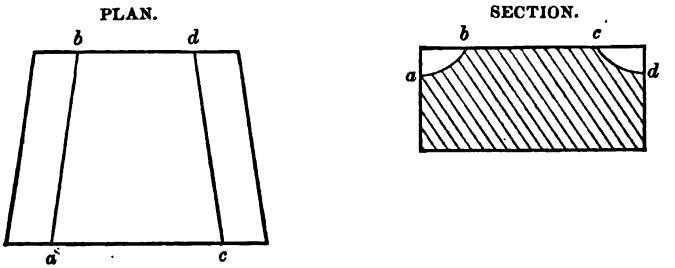
The damage done to the miter-sills of these gates was almost precisely like that described above. The exception is that no stone was lifted entirely out of its place, as in case of the stones *a* and *b*. A peculiarity here was that the arch, although slightly raised from its bed, was so firmly pressed together that although the water had washed out the

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joint under it, (joint *c d*, section of the upper lift-gate on the line A B, "Old condition,") that, when I attempted to relay it, I could not have taken a single stone out of it unless by cutting it to pieces; and we were compelled, in relaying it, to make the joint tight below and force the mortar in from above, and then settle it firmly on the bed. The gates were also out of miter.

MIDDLE LIFT-GATES.

The damage done to the miter-sills of these gates was almost precisely like that just described. The exception was that the arch-stones did not stand as well. The second stone in the arch from the north wall of the chamber (marked *c*, plan of miter-sills, "Old condition,") was crushed, and in relaying the sill I replaced it by another stone. The stones marked *f* and *g*, on the same plan, had two pieces crushed out along their two normal edges, thus:



a b and *c d*, in both plan and section, show the line of rupture. The gates here were also thrown out of miter, and there was one effect peculiar to these gates. The straining-rod, which runs from near the top of the miter-posts to the middle of the bar, next to the lower bar of the gate, is fastened to the miter-post by a bolt running completely through the latter. This bolt was broken off on both gates close to the face of the posts.

LOWER LIFT-GATES.

The miter-sills of these gates could not be examined until about twenty days after the others were. In order to remove the rock ledge which existed in the bed of the river, just at the outlet of the locks, a coffer-dam, inclosing this ledge, was built. This coffer-dam extended from the river-bank, just north of the locks, to a point on the bank about 640 feet below the locks. The water which came through the new locks filled up the space thus inclosed, and, although I cut the dam, the river was so high that I could not reduce the height of water lower than to a point about 8 feet above the miter-sill, and was compelled to hire powerful pumps to remove it. After this was done, I found the sill affected precisely like that of the guard-gates at the head of the locks. The gates were considerably more out of miter than either of the others, their miter-posts touching only a short distance from the top, and their lower ends being carried down stream, that of the north gate about 8 inches more than that of the south gate.

Upon removing the various miter-sills, with a view to relaying them, it was found, under the two upper miter-sills, that the foundation had been considerably opened for a depth ranging from 6 to 16 inches. As

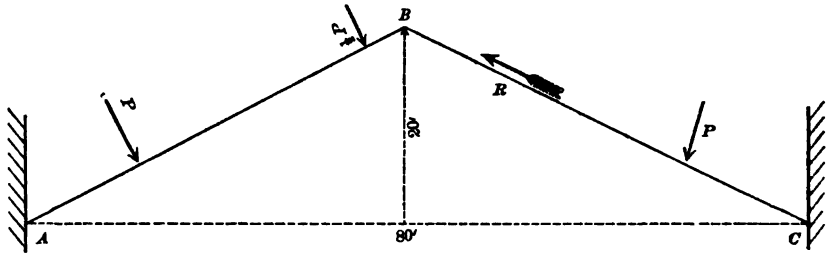
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the whole of this canal (locks included) is excavated through rock, powder was necessarily used in excavating these chambers. Undoubtedly the bed of the chambers was shattered by the explosion nearest to it, and the water soon found the seams or crevices thus produced, and exposed them.

The foundation of the sill of the middle lift-gate was found to be solid limestone rock, and without a flaw.

Under the miter-sill of the lower lift-gates a seam of limestone was found, about 4 inches thick, at the south wall of the locks, and increasing gradually to 14 inches in thickness at the north wall. Before relaying the sills of the upper two and the lower gates, all these defective portions of the foundation were removed, and a bed of pure cement concrete substituted.

As soon as I saw the effect produced on the miter-sills, I concluded that the damage was produced in the manner stated by the board of engineers; but the action should not have occurred, as you will readily see as follows:



Let us take, for a moment, the same case as the one taken by the board. Let A B and B C represent the upper edge of the miter-sill of the guard-gates, or, which is the same, the inner face of these gates when closed. At the time the vertical motion of the gates took place which opened the way to the water for the destruction of the sills, the water stood against the gates at a height of 9 feet above the sills, and consequently 9 feet 6 inches above the under surface of the lower bar of the gate. The area of this bar is so nearly 24,400 square inches that it can be assumed as that. The upward pressure on each square inch of this surface due to a head of water of 9½ feet is 4.45 pounds. The whole upward pressure on the lower bar of each gate was, therefore, 108,580 pounds. The weight of the gates is about 85,000 pounds, and consequently another pressure, to equal or exceed the difference between the two, (23,580 pounds,) should be provided for. This was theoretically provided for in the combination. For at the moment, we assume, there being 9 feet of water against the gates, each gate being 47⅔ feet long, and assuming this muddy water to weigh only 64 pounds per cubic foot, the pressure, P, against each gate was $47\frac{2}{3} \times 9 \times 4\frac{1}{2} \times 64 = 122{,}912$ pounds, or, in round numbers, 123,000 pounds. Now, one-half the pressure on each gate is borne by the hollow-quoin, and the other half by the opposite gate. Each gate was, therefore, subject to a pressure, at its miter-post, of 61,500 pounds, in a direction oblique to its axis.

In order that there shall be perfect stability at the surface of contact of the miter-posts in the direction of the axis of the gate, the cross-pieces of the gate should have developed a resistance which is measured by the following equation, (representing the resistance by R:)

$$R = \tfrac{1}{8}\, w\, h\, b\, y\, \sqrt{n^2 + 4},$$

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in which w is the width of the locks, h the head of water, b the distance of the center of gravity of the water below its surface, y the weight of a cubic foot of water, and $\sqrt{}$ the quotient which arises from dividing the width of the locks (80 feet) by the versed sine (20 feet,) of the miter-sills. Substituting these values in the above equation, we have—

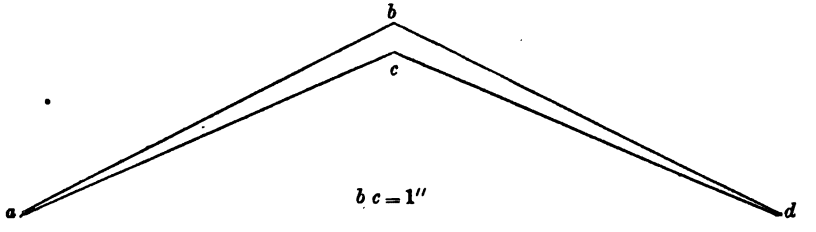
$$R=\tfrac{1}{8}\times 80\times 9\times 4\tfrac{1}{2}\times 64\times 4.47=115{,}862 \text{ pounds.}$$

But this resistance of the cross-pieces is directly transmitted to the heel-post, and each of the latter was therefore pressed against the hollow quoin to which it fits closely by two pressures, amounting to 127,362 + pounds. But the co-efficient of friction of oak on stone is 4, and therefore the resistance to a vertical motion at each heel-post due to the friction should have been 50,944 + pounds, which is far in excess of the amount to be provided for to insure stability in the structure.

The miter-post should have been firmly held by the forces of friction developed, as will be seen by a simple calculation, remembering that they are of oak and painted, and therefore the co-efficient of friction is fully 5.

Now, the gates did move in a vertical direction at the miter-posts. They could not move at the heel-posts, because these were firmly held by the strong iron collar which encircles them at the head, and this proves that the forces of friction which should have been developed in theory were not developed in practice, and the reason of this I am confident is as follows, and gives the true cause of the disaster.

When the contractors (H. T. Cook & Co.) had finished the gates and wished me to accept them, they were in position in their recesses in the side-walls. I declined to accept them until they had been closed, to see whether they would fit, and until they had been "operated to the satisfaction of the engineer," as the language of the specifications required. This closing and operating involved the removal of a considerable quantity of mud, and hence the contractors took the position that as they had built the gates precisely according to the drawings and specifications, I ought to accept them, as they were. I declined to do this, and insisted upon it that the gates must be closed, to see how they fitted, and whether the machinery all worked right. The contractors hesitated about three weeks before doing this, but finding that I would not relent, they did as I directed. Upon closing the gates, it was found that at the miter-posts they stood about one inch from the miter-sill, thus:



in which $a\ c$, and $c\ d$, is the face of the sill, and $a\ b$, $b\ d$, the face of the gates. Before I would accept them then, and pay for them, I compelled the contractors to change every one of the sticks of timber which formed the cushion in the sill against which the lower bar of the gates rest, so that there should be a close fit. This also involved an expense of about $400, but I insisted upon it. I reasoned in this manner: the material of which the gates are constructed was purchased about

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eight years previous, by the canal company. The different portions were all prepared, so that all we had to do was to put them together. The timber and lumber had been during this time under roof, and had become thoroughly seasoned and dry, and I therefore supposed as soon as it became saturated it would swell sufficiently to make, under the water-pressure, a perfect contact at the miter-posts. But the water came against them in much quicker time than was required for the timber to swell, and consequently, when the pressure came against them, the miter-sills being firm, the gates were slightly moved into the hollow quoin by the component of the pressure in the direction of the length of the gates, (which was larger than the force of friction developed between the lower bar and the timber cushion of the sill,) and thus the contact between, and with it the friction at, the miter-posts destroyed. Then the buoyancy of the gates had no resistance except their own weight, and the damage was created as the board of engineers report. Thus, in attempting to do a thing right, I overdid it from want of experience in such structures. I am confident that if I had allowed the sills and gates to remain as they were offered by the contractor, this thing would not have occurred, but then it might have thrown too much strain on the gates.

Now, when I came here to supply my want of experience in these constructions, I did just as you advised me to do. I wrote to Mr. Milnor Roberts, and he sent me two assistants of experience, and I have read every work I could reach on the subject of locks, even sending to Europe for two works, at a large expense. But the trouble is that no locks were probably ever built, or ever will be built again, where the gates are put together eight years after all their parts are framed, and all this assistance and information, to me thus gained, was of no practical value in this instance.

In reconstructing the sills, I decided at once to make the sill a combination of wood and stone. Instead of the timber cushion, I placed in two oak timbers, 12 by 14 inches, on the 12-inch edge; a thick layer of coal-tar between them, and firmly bolted together by 1½ inch rag-bolts, driven in 3 feet apart. I could get no timbers of larger size. Wherever there was the least doubt of the foundation, we excavated to a firm surface, and filled up with a bed of cement concrete. These timbers are bolted to the rock by two-inch bolts, driven into a wedge, as shown on the unnumbered sheet, under the head of "New Condition." The head of each of these bolts bears upon a circular iron washer to prevent injury to the timber. The stones of the sills on which the timber-cushion rested were cut to fit this timber-sill, and they, with all of the remainder of the stones, were carefully relaid.

Every stone is bolted down with a 1½-inch bolt driven into a wedge. In order to prevent injury to the stone in driving these bolts, I had a screw cut into their heads, and in order to distribute the strain over as much surface of the stones as possible, I placed a square iron washer around them, and then, by means of a nut, fastened this washer firmly to the stone. I had already purchased the iron before I was informed that the board recommended 2-inch bolts. When I told the members that I had already purchased 1½-inch iron, they told me to go right on as I was doing. There is no question that the 1½-inch bolts are amply strong enough. For, as the river rises so much faster at the foot of the falls than it does at the head, the greatest head of water that the gates are subject to are about as follows: guard and upper lift-gates, 14 feet; middle lift-gates, 24 feet; lower lift-gates, 10 feet.

The joint between the timber and stone portion of the sills is thoroughly

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calked with oakum saturated with coal-tar. I separated the wood and stone portions, because I saw that with the old arrangement a disaster just like this one could easily be produced at any time either by carelessness or design in not properly closing the gates before letting on the water. All of the arches are now firmly abutted into the side walls.

Now, with regard to the inferiority of the material of the miter-sills referred to in the report of the board of engineers, I have to say that the new locks of the Louisville and Portland Canal were designed in 1860 by Mr. Theodore R. Scowden, civil engineer, who was employed by the canal company for that purpose, and for superintending their construction. After the lock-walls and two of the miter-sills had been built, the material for the gates prepared, a large part of the machinery for operating the gates and the stones for the remaining miter-sills prepared and delivered on the site, the funds of the canal company were exhausted, and all further operations were suspended until 1869, (several years thereafter,) when I resumed work on them. During this time the backwater of the river, in high stages, filled up the locks, and nearly completely filled up both chambers with sediment which it deposited. The stones of the miter-sills were thus excluded from the air, and have not yet had an opportunity to harden like those in the walls. Every stone used in the construction of these locks, or any part of them, came from the same quarry. It is a coarse brown limestone, known as the Cannelton stone, and is of the same character as that employed in all the locks in this section of the country. The experience gained with locks over forty years old in this vicinity leads me to have no fears whatever for the miter sill-stone, but if any stone should prove defective by the peculiar manner in which they are bolted down, it could be easily replaced.

In conclusion, I desire to say that, in considering this whole subject, it must be borne in mind that these locks are the pioneer canal-locks of their size in the world, and that many things will probably be learned here that will be of practical benefit to the profession. For, although the principles of all locks and their various parts are the same, it is a well-known fact that they are among the most delicate constructions to handle, even if of only ordinary size, and that accidents are of frequent occurrence. For this reason I have considered it my duty, rather than recklessly to reject the valuable material that was on hand, to give Mr. Scowden's design a fair trial, and then to recommend such changes as experience would indicate. I believed that I could do this with perfect safety after examining his plans, and particularly as he is a gentleman who had made a reputation as a hydraulic engineer when I was a boy. He receives to-day, from the cities of Cincinnati, Ohio, and Newport, Kentucky, a salary, as engineer on their water-works, (constructions which will cost at least $6,000,000,) which is larger than that of a major-general in the Army, and the old water-works at Cincinnati, the new ones here, and at Cleveland, Ohio, are monuments of his ability. This fact is so well known that General Wilson, when placed in charge of the improvement of the Des Moines and Rock Island Rapids, came here and copied the plans, and I have furnished Major Poe tracings of all the most important drawings, at his request. Besides that, several civil engineers have copied them.

I am, sir, very respectfully, your obedient servant,

J. WEITZEL,
Major of Engineers.

Brigadier General A. A HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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L 4.

LOUISVILLE AND PORTLAND CANAL.

LOUISVILLE, *December* 19, 1871.

GENERAL: I herewith transmit a report of the special board of engineers, convened by Special Order No. 161, paragraph 2.

I am, respectfully, your most obedient,

J. G. BARNARD,
Colonel of Engineers and Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers.

LOUISVILLE, KENTUCKY, *December* 19, 1871.

GENERAL: The board of engineers detailed by special orders No. 161, paragraph 2, "to examine the new locks of the Louisville and Portland Canal, and report the cause of the giving way of the miter-sills, reported by Major Weitzel to have taken place on the morning of November 23, and to prepare a plan for their modification and repair, or for new sills," assembled, (with the exception of General J. H. Wilson, who did not attend,) at Louisville, on the 18th, and, accompanied by Brevet Major-General Weitzel, visited and carefully examined the injuries sustained by the miter-sills, and, concerning the cause of their failure and the remedy therefor, respectfully report as follows:

The miter-sill, according to the original construction, was a timber 10 by 10 inches, let into a rebate in the miter-stones and bolted to them. These stones, two feet in depth, rest on the rock floor of the upper bay, and, except those at and near the miter point, extend back so as to abut against the crowning voussoirs of the lift-wall. In the case, however, of the upper or guard-gate miter, and of that of the lowest lock-gate, there is no lift-wall, and the abutment voussoirs alone exist, forming what may be called the miter-arch.

The miter-stones first alluded to have an average width of from 5 to 6 feet, and a length somewhat greater, but the three stones at the miter-point are wider and, at the same time, shorter, the space between them and the voussoir-stones being filled up by four intermediate stones, against which they abut.

It should be remarked that, according to the original plans, the arched lift-wall, or (where they do not exist) the miter-arches, should have had their abutment upon a cushion-stone in the side-walls. Through some modification in that plan, these arches were built, in some cases, without such abutment. Such was the case with the miter-arch of the lower gate and of the guard-gate.

The 2 feet of thickness of the miter-stones constitute the whole height above the rock floor of the upper bay of the miter-wall. The arch voussoirs against which the stones abut had the same height of 2 feet. The stones, both miter and voussoir, though of a very inferior material, appear to have been well fitted and laid.

Inasmuch as the constructions which we have described had all been taken up, the injuries they received cannot be described from observation. Their nature, it is presumed, has been accurately made known to you by the engineer in charge, General Weitzel.

In default of accurate notes of the occurrences which followed the introduction of the water on the morning of the 23d of November, we are left to conjecture or infer the exact *rationale* of the giving way of the sills. Confining our attention, for the moment, to the guard-gate and sill at the head of the lock-structure, and premising that the lock-chambers were all empty and the gates all closed, it appears that, upon letting the water into the upper bay, it rose against the gates until it obtained a depth or head of about 9 feet. Of course the lower beams of the gates were pressed with great force against the wooden miter-sill, forming a water-tight joint.

The pressure due to a head of 9 feet was therefore brought into action upon the entire area of the bottom of the gate. Taking a single gate, this area may be roughly estimated at 160 square feet, the upward pressure upon which would be about 100,000 pounds. The gate is stated to weigh about 83,000 pounds. An upward pressure, over and above the weight of the gate, of about 17,000 pounds, would therefore be developed. The enormous pressure by which the wood surfaces of the gate and miter-sill were pressed together, would develop a force of friction quite sufficient to transmit this uplifting force to the miter-stones, and it would probably be *sufficient* to lift the outer ends, bearing in mind that the slightest crevice produced *under* a stone would admit the water and add to the upward-acting force a powerful pressure under the stone itself. So appears to have been caused the actual uplifting of the outer ends of the miter-stones.

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The powerful pressure transmitted to the stones in their rear, aided by the lifting-force acting on their under surface, transmitted by friction at the joints to these rear stones, might in turn start *them* from their beds, and admit the water-pressure under *them* also. Accordingly we find one of the intermediate stones belonging to the miter-wall of the upper gate, and another belonging to the wall of the second gate, and still another in the wall of the lowest gate, to have been actually lifted out of their beds and carried away by the subsequent rush of water.

Without having an accurate record of the phases of the occurrence, we presume, inasmuch as the injuries sustained were at every individual gate essentially the same, that what we describe as having occurred at the upper gate repeated itself at each of the others. We have also reason to believe that, owing to want of abutment, the lowest miter-arch was slightly started back.

Passing now to the question of "modification and repair," we find that the engineer officer, General Weitzel, has already far progressed in the resetting of the sill, with modifications well designed and well suited to prevent any future yielding. His method of repair consists in taking up the whole miter-structure, (including, except in one instance, the voussoir-stones,) excavating the rock underneath to a depth of from 6 to 16 inches, in order to remove all loose portions of the bed-rock and to provide space for a bed of concrete, cutting away the front end of the miter-stones, so as to allow a wooden miter-sill, 28 inches deep, (consisting of two pieces of timber, each 12 by 14 inches,) to extend all the way down to the concrete. This sill, firmly bolted by 2-inch iron bolts to the bed-rock, cannot be lifted by any force proceeding from the water-pressure under the gate. Hence the stones behind will not be subjected to upward displacement by forces thence transmitted. The miter and voussoir stones have been carefully relaid, and bearings formed in the side-walls for the miter-arches in the cases alluded to, where they were wanting.

The upper (guard-gate) sill has been completed; the second-gate sill, nearly so; the third, completed; the fourth, reconstruction just commenced.

We deem the modifications introduced as well designed, and that they will be effectual and sufficient, as against a repetition of the degradations under the form in which they recently actually occurred. We have but one recommendation to make, suggested by the demonstrated power of the water to force out, *by its direct pressure on their under surfaces*, stones quite removed from the action of upward forces, transmitted from the gate. In the *actual* instances, doubtless the gate action was the agent in opening the way for the water to the joints under the stones in question.

Nevertheless, owing to the seamy character of the bed-rock, and the liability to slight disturbances which may permit the penetration of the water underneath the stones, we deem it well to secure every stone of the voussoir and miter against the liability to such upheaval by a 2-inch bolt through each miter (and intermediate) stone into the bed-rock, and through each voussoir into the third course below, (*i. e.*, into the third course, counting from the top,) recommending, as causing least disturbance in the beds of stones already set, the use of the diamond drill for drilling the bolt-holes.

This additional security will be quite inexpensive, will very little retard the opening of the locks, and will, we think, render these sills entirely secure not only against such defections as have occurred, but against any cause of failure that we can foresee.

Respectfully submitted.

J. G. BARNARD,
Colonel of Engineers, and Brevet Major-General.
J. G. FOSTER,
Lieutenant-Colonel Engineers, and Brevet Major-General, U. S. A.
O. M. POE,
Major of Engineers, Brevet Brigadier-General, U. S. A.

Brigadier-General HUMPHREYS,
Chief of Engineers, United States Army.

L 5.

CUMBERLAND RIVER BELOW NASHVILLE, TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 1, 1872.

GENERAL: I have the honor to submit the following report of the operations at the improvement of the Cumberland River below Nashville, Tennessee, during the fiscal year ending June 30, 1872.

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Since my last annual report the contractor has prosecuted his work with as much energy as was possible, until the high water drove him from his work. He has removed the old foundation at Nashville, the obstructions at Nashville and Gower's Island; has dredged 1,100 cubic yards at Flax Patch; has constructed 7,580 cubic yards rip-rap dam at the same point, and has excavated 300 cubic yards of rock at Harpeth Island. It is believed that his contract will complete the improvement of the river as far as Sycamore Creek, and that he will undoubtedly complete it during this season if the weather is favorable.

By your letter of the 19th of June, 1872, I was informed that $20,000 had been appropriated by the act of June 10, 1872, for the improvement of the Cumberland River. The project for its expenditure submitted by me having been approved, I applied for authority, by letter dated June 25, 1872, to advertise for bids for continuing the work from Sycamore Creek to Reed's Reef.

The total amount required for the completion of this work, according to the data we now have on hand, as reported in my special report on the survey of the Cumberland River, dated January 25, 1872, is, $248,821.

Appropriated by act of March 3, 1871	$30,000
Appropriated by act of June 10, 1872	20,000
Total appropriated	50,000
Total still to be appropriated	198,821

This amount could be profitably expended during the fiscal year ending June 30, 1874, and should be appropriated. But if this cannot be done, at least $60,000 should be appropriated to remove the obstructions at Harpeth Shoals. It is well nigh impossible to get experienced and able contractors to bid reasonably on work of so small amount as the appropriation made by the last Congress.

The river flows through several collection-districts, the designation of which I cannot ascertain.

The nearest port of entry is Louisville, Kentucky. The amount of revenue collected at this port during the fiscal year ending June 30, 1872, was $122,296.14.

The commerce and navigation of the Mississippi River, and all of its branches, would be benefited by the completion of this work.

The amount of cash received for this work during the fiscal year ending June 30, 1872, was $20,000; the amount expended during the same period was $15,901.57.

The amount of appropriation available June 30, 1872, was $14,098.43, all of which will be expended during this season.

The amount required for the fiscal year ending June 30, 1874, is $198,821.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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L 6.

WABASH RIVER, INDIANA.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 1, 1872.

GENERAL: By your letter of the 19th of June, 1872, I was informed that $50,000 had been appropriated for the improvement of the Wabash River, beginning at its mouth, and I was directed to prepare a project for its expenditure.

I submitted this project under date of June 25, 1872, and have this day received the approval thereof.

I will advertise for bids for the work as soon as the specifications are prepared and authority is received.

The total amount required for the completion of this work (see special report, dated January 4, 1872) is	$310,452 62
Amount appropriated by act of June 10, 1872.....	50,000 00
Total still to be appropriated.....	260,452 62

At least $125,000 of this amount should be appropriated for the fiscal year ending June 30, 1874, to enable me to rebuild the locks at Grand Rapids.

The river flows through several collection districts, the designations of which are unknown to me.

The nearest port of entry is Evansville, Indiana. The amount of revenue collected at this port during the fiscal year ending June 30, 1872, was $121,333.44.

The commerce and navigation of the Mississippi River and all its branches would be benefited by the completion of this work.

No money was received and none expended on this work during the fiscal year ending June 30, 1872, but all the money appropriated will undoubtedly be expended during the present fiscal year.

The amount of the appropriation available July 1, 1872, was $50,000.

The amount required for the fiscal year ending June 30, 1874, and which can be profitably expended, is $125,000.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

L 7.

SURVEY OF THE UPPER CUMBERLAND RIVER.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, February 8, 1872.

GENERAL: I have the honor to submit the following report on the survey of the Upper Cumberland River:

The party, under the immediate direction of Mr. S. T. Abert, civil engineer, took the field in July, 1871, and completed the field-work of the survey in November of the same year, after encountering great diffi-

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culties on account of the exceedingly low stage of the river, and sickness among the men.

The character of the country through which the Upper Cumberland flows, and the character of its own bed, were so fully described in my report of January 20, 1871, that it is not considered necessary to say anything additional on these subjects in this report.

Adopting the same divisions of the river which were adopted in the report of last year, the facts developed by this survey are as follows, viz:

First division.—Extending from Laurel River to the South Fork. The obstructions in this division until Smith's Shoals (also called the "Great Shoals") are reached, twenty-four miles from Laurel River, consist in heavy gravel bars, rocky *débris* and ledges, and detached masses of rock. The descent is 1.29 feet per mile.

At the obstruction known as "Smith's Shoals," or the "Great Shoals," the river flows over ledges of limestone which resemble broad, descending steps. At two points there is a vertical descent of two and a half feet. The total descent of these shoals in nine miles, including the intervening pools and the descent, is 54 feet, or at the rate of 6 feet per mile. The greatest descent is at four localities, known as Shadowen Shoal, White Cliff Ripple, Long and Short Shoals.

Coal-barges have, in high stages of the river, navigated these shoals during the last thirty-five years, but with frequent losses.

Second division.—Extending from the South Fork to Nashville. The main features of this division resemble those of the first division, but are less formidable in their character.

The entire distance from Point Burnside, the head of steamboat navigation, and the point at which the South Fork empties into the Cumberland River, to Nashville, is 326.71 miles, and the descent is 232 feet, or at the rate of 0.71 foot per mile.

The following table gives all the facts which were obtained by the survey of this division:

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Table giving the facts obtained by the survey of the second division, extending from the South Fork to Nashville.

Locality between Point Burnside and Nashville.	Distance from Point Burnside.	Length of each shoal and pool in succession.	Descent of the river.				Depth of low water.	Difference of level from Point Burnside.	Remarks.
			Fall of each shoal and pool.		Maximum fall in a given distance.				
			Total.	Average per mile.	Feet fall and distance.	Corresponding rate per mile.			
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet. Distance.*	*Feet.*	*Feet.*	*Feet.*	
Point Burnside	0.							0.00	
Fishing Creek	5.								Sand and gravel bar.
Ford's Island	6.								
Cowan Shoal	7.								Rocky channel.
Forbush Bar	13.	0.33							Rocky reef at head and foot.
Gan's Island	23.								Right channel rocky.
Harmon's Island	29.								Rock to be removed.
Lilly or Wolf Island	34.								Short dam and rock excavation.
Belk's Island	37.								Trees and logs.
Wild Goose Shoal	45.3	0.57	3.25	5.70	0.457 in 300	8.03	0.5 to 3.2	40.25	Flat rock on left, and gravel bars.
Natural pool	45.87	2.08	0.82	0.39			2.4 to 7.6	41.07	
Indian Creek, Poplar Mountain	47.95	0.26	1.432	5.51	0.89 in 560	8.4	0.8 to 2.0	42.502	Large river stone.
Natural pool	48.21	1.80	0.683	0.38			2.8 to 9.9	43.185	
Long Bottom Island	50.01	0.31	0.833	2.69	0.74 in 1,000	3.93	1.3 to 5.7	44.018	Rocky rapids.
Natural pool	50.32	1.40	0.01	0.007			5.4 to 9.9	44.028	
Boyd's Island	51.72	0.18	0.266	1.48	0.266 in 960	1.46	1.2 to 5.5	44.291	Gravel-bar in right channel.
Natural pool	51.90	1.13	0.01	0.008			4.9 to 15.0	44.304	
Black Fish Bar	53.03	0.49	3.066	6.26	1.24 in 400	16.37	0.4 to 3.8	47.37	Flat gravel-bar.
Natural pool	53.52	1.10	0.07	0.06			3.0 to 8.3	47.44	Nettie Miller rock.
Blankwiship's Bar	54.62	0.49	0.239	0.55	0.239 in 2,600	0.55	0.4 to 4.6	47.679	Channel on left ripple at head.
Natural pool	55.11	0.91	0.089	0.098			1.7 to 7.3	47.768	
Campbell's Island	56.02	0.66	2.143	3.24	0.765 in 700	5.75	1.5 to 5.2	49.911	Crooked channel, gravel-bar, snags.
Natural pool	56.68	2.37	0.944	0.39			1.1 to 10.0	50.855	
Snow Island	59.05	0.78	1.726	2.21	0.607 in 300	10.66	0.4 to 7.7	52.581	Gravel-bar.
Natural pool	59.83	1.58	1.302	0.19			2.4 to 10.6	52.853	
Winfrey's Island	61.41	0.77	2.233	2.90	0.525 in 500	5.54	0.8 to 4.4	55.116	No special obstruction.
Natural pool	62.18	1.31	0.301	0.229			1.5 to 15.6	55.417	In navigable stages.
Winfrey's Ford	63.49	0.21	0.850	4.05	0.85 in 1,100	4.05	0.5 to 3.9	56.267	
Natural pool	63.70	3.62	0.073	0.020			2.16 to 13.0	56.34	
Self's Shoal	67.32	0.13	0.982	7.55	0.982 in 700	7.55	0.6 to 4.1	57.322	Flat gravel-bar and rock.
Natural pool	67.45	3.73	0.597	0.16			1.9 to 9.1	57.919	
Willis's Creek	71.18	0.36	1.559	4.33	1.392 in 700	10.50	0.5 to 3.0	59.478	Ripple at head over gravel.

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Table giving the facts obtained by the survey of the second division, &c.—Continued.

Locality between Point Burnside and Nashville.	Distance from Point Burnside.	Length of each shoal and pool in succession.	Descent of the river.				Depth of low water.	Difference of level from Point Burnside.	Remarks.
			Fall of each shoal and pool.		Maximum fall in a given distance.				
			Total.	Average per mile.	Feet fall and distance.	Corresponding rate per mile.			
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet. Distance.*	*Feet.*	*Feet.*	*Feet.*	
Natural pool	71.54	1.53	0.432	0.28			2.5 to 7.1	59.910	
Spearman's Island	73.54	0.51	0.674	1.32	0.46 in 1,200	2.02	0.5 to 5.2	60.584	Gravel-bar, short.
Natural pool	73.58	3.26	0.334	0.10			1.4 to 10.1	60.918	
Crocus Creek Bar	76.84	0.23	0.979	4.26	0.979 in 1,200	4.26	0.8 to 5.3	61.897	Bar on left, leaving good water.
Natural pool	77.07	1.21	0.116	0.09			3.7 to 11.3	62.013	
Baherton Bar	78.28	0.19	0.626	3.29	0.626 in 1,200	3.29	1.4 to 5.0	62.639	Narrow channel on left.
Natural pool	78.47	1.93	0.300	0.15			2.6 to 8.7	62.939	
Short Bar	80.40	0.15	0.496	3.30	0.496 in 800	3.30	0.6 to 1.7	63.435	Gravel excavation.
Natural pool	80.55	0.17	0.007	0.04			2.4 to 5.4	63.442	
Rennix Bar	80.72	0.21	0.808	3.56	0.808 in 1,100	3.56	2.5 to 6.2	64.25	Gravel delta from mouth of creek.
Natural pool	80.93	1.31	0.107	0.08			5.6 to 10.4	64.357	
Scott's Island	82.24	0.28	0.027	0.10	0.85 in 800	0.56	2.7 to 8.5	64.384	Good water.
Natural pool	82.52	0.61	0.042	0.07			7.5 to 8.5	64.426	
Goose Creek Bar	83.13	0.23	0.184	0.80	0.079 in 400	1.04	1.7 to 7.4	64.61	Do.
Natural pool	83.35	4.96	0.215	0.04			3.0 to 14.6	64.825	
Beer Creek	88.32	0.49	0.043	0.09	0.018 in 1,000	0.09	5.0 to 11.6	64.868	Do.
Natural pool	88.81	1.50	0.129	0.08			8.8 to 15	64.997	
Walton Shoal	90.31	0.61	2.416	3.96	2,306 in 1,100	11.07	0.5 to 31	67.413	Irregular channel, rock and gravel.
Champ Shoal	92.85	0.76	3.40	4.47	1,934 in 900	11.35	0.3 to 3.0	70.945	Ledges of rock-crossing.
Natural pool	93.61	3.77	0.147	0.04			1.7 to 11.9	71.092	Channel diagonally, gravel.
Wilburn's Island	97.38	0.49	2.775	5.66	1.216 in 300	21.38	0.4 to 6.8	73.867	Best channel on the left, but narrow; obstructed by gravel.
Natural pool	97.87	1.19	0.057	0.05			2.4 to 8.6	73.924	
Gallaway's Bar	99.06	0.15	1.19	7.93	0.955 in 600	8.39	0.2 to 7.0	75.114	Ledge of rock.
Natural pool	99.21	1.29	0.421	0.30			1.6 to 7.4	75.535	
Murphy's Bar	100.5	0.19	0.247	1.30	0.093 in 300	1.64	0.5 to 7.9	75.782	Ledge of rock.
Natural pool	100.69	3.01	1.164	0.38			0.8 to 10.2	76.946	
Cloyd's Island	103.70	0.61	0.455	0.75	0.315 in 2,000	0.83	1.4 to 9.3	77.401	Good channel.
Natural pool	104.31	0.66	0.001	0.0015			7.8 to 11.9	77.402	
Mud Camp Bar	104.97	0.43	2.607	6.29	1.398 in 300	24.6	0.4 to 9.4	80.008	Rock at head, wide gravel-bar.
Natural pool	105.40	1.41	0.75	0.53			1.0 to 10.5	80.758	
Stallcup's Island	106.81	0.30	1.514	5.04	0.997 in 800	6.58	1.3 to 5.3	82.272	Good channel.
Natural pool	107.11	2.18	0.313	0.10			1.6 to 13.5	82.584	

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Incrusted Island	110.29	0.47	1.469	3.13	0.675 in	500	7.13	0.6 to 5.2	84.054	Crooked channel, gravel-bar and rocky re
Natural pool	110.76	0.38	1.404	0.52				1.0 to 10.8	85.462	
Kirkpatrick's Bar	117.14	0.58	1.554	2.77	0.649 in	700	4.89	0.5 to 3.7	87.016	Gravel-bar and rocky reefs.
Natural pool	117.70	4.89	1.885	0.39				1.1 to 11.6	88.901	
Simms's Bar	122.56	0.37	1.595	4.31	0.879 in	600	7.73	0.5 to 2.8	90.498	Ledge of rock at head.
Natural pool	122.53	5.90	2.393	0.39				1.0 to 10.5	92.819	
Simms's Ford	128.83	0.26	1.361	5.23	1.115 in	700	8.41	0.8 to 2.8	94.181	Ledge and detached rock.
Natural pool	129.00	0.77	0.268	0.35				1.0 to 5.0	94.448	
Kittle Creek Shoal	129.86	0.43	2.328	5.41	1.813 in	900	10.63	0.8 to 3.6	96.776	Gravel-bar and rock.
Natural pool	130.29	0.53	0.089	0.17				2.7 to 4.3	96.866	
Shut-in Shoal	130.82	0.06	1.629	27.15	1.629 in	309	27.15	0.6 to 1.8	98.495	Crooked and narrow.
Natural pool	130.88	3.18	0.592	0.18				2.8 to 6.8	98.495	
Celina Bar	134.06	0.25	2.335	9.42	1.905 in	700	15.05	0.5 to 6.0	101.442	Gravel, snags, and rocks.
Natural pool	134.31	2.14						1.0 to 8.9		
Knob Creek	136.45	0.17						0.8 to 3.1		Snags and logs.
Natural pool	136.62	6.96						1.0 to 12.6		
Turkey Creek Island	143.58	0.91						0.8 to 6.3		Long Delta Island, contracted channel with gravel-bars.
Natural pool	144.49	1.48						4.4 to 12.1		
Brimstone Island	145.97	0.82						0.7 to 6.8		Delta Island, crooked channel, gravel-bars.
Natural pool	146.79	1.02						2.2 to 14.4		
Kirkpatrick's Bar	147.81	0.17						0.7 to 5.5		Land channel on left.
Natural pool	147.98	0.86						2.1 to 13.1		
Scantlin Island	148.84	0.79	4.441	5.62	1.478 in	200	39.92	0.6 to 9.5		Crooked channel, obstructed with rock and gravel.
Natural pool	149.63	0.52						2.6 to 14.6		
Hamilton Bar	150.15	0.30						0.5 to 14.1		Short gravel-bar.
Natural pool	150.45	8.86						1.0 to 20.6		
Simpson Island	159.31	1.14	2.730	2.39	0.797 in	200	21.04	0.4 to 7.7		Gravel bar and snags at lower end of island.
Natural pool	160.45	0.47						6.4 to 19.4		
Witche's Bar	160.92	0.55	0.426	0.77	0.133 in	500	1.4	1.1 to 6.0		No obstruction.
Natural pool	161.47	0.63						11.6 to 18.5		
Crib Creek Island	162.10	0.79	3.93	4.97	1.68 in	250	34.87	0.7 to 6.2		Channel irregular, gravel bars at head and foot.
Natural pool	162.89	1.65						4.4 to 18.4		
Brook's Island	164.54	0.19						1.0 to 3.7		No obstruction.
Natural pool	164.73	1.4						1.9 to 17.9		
Ray's Bar	166.12	0.19						1.0 to 3.5		No obstruction.
Natural pool	166.32	2.08						1.3 to 16.9		
Sackett's Island	168.4	0.38						1.0 to 5.3		No obstruction.
Natural pool	168.78	1.21						2.8 to 7.2		
Denin's Bar	169.99	0.21						1.8 to 2.7		No obstruction.
Natural pool	170.2	5.21						2.3 to 24.4		
Salt Lick Island	175.41	0.76						0.6 to 6.3		Rock excavation, small.
Natural pool	176.17	3.20						2.7 to 14.9		
Upper Holliman Island	179.37	0.78						3.0 to 6.0		Fragments or rock resembling a dam.
Natural pool	180.15	0.62						4.6 to 12.9		
Widow Holliman's Island	180.77	1.23	4.235	3.44	2.175 in	1,100	10.44	1.2 to 3.7		Bar at head of island and conflicting channels.
Natural pool	182.00	1.39						2.9 to 11.5		
Indian Creek Shoal	183.39	0.79	5.002	6.33	2.372 in	500	25.05	0.5 to 6.0		Obstructing rock at head and foot: logs and trees in right chute.
Pool	184.18	2.69						2.4 to 16.4		

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Table giving the facts obtained by the survey of the second division, &c.—Continued.

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			Fall of each shoal and pool.		Maximum fall in a given distance.				
			Total.	Average per mile.	Feet fall and distance.	Corresponding rate per mile.			
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet. Distance.*	*Feet.*	*Feet.*	*Feet.*	
Sullivan's Island	186.87	0.38					0.6 to 0.32		Short bar, not serious.
Natural pool	187.25	3.60					0.9 to 18.4		
Card Rock Bar	190.85	0.13					1.6 to 5.4		No obstruction.
Natural pool	190.98	1.69					2.9 to 21.4		
Beasley's Bar	192.67	0.21					1.4 to 5.6		No obstruction; shags.
Natural pool	192.88	3.18					2.9 to 20.9		
Sand Shoals	196.06	0.84	4.445	5.26	1.037 in 310	17.66	0.5 to 2.7		Gravel and rock excavation and short dam; right-hand channel to be improved.
Natural pool	196.90	5.84					0.8 to 7.4		
Rock Shoals } Natural pool	197.34						0.8 to 1.4		Merely a narrow ledge of rock. Small rock excavation.
Buch Shoals }	199.34						0.8 to 1.1		Do.
Turkey Creek Shoal	202.74	0.78					0.6 to 6.7		Short gravel-bar.
Natural pool	203.52	3.61					1.4 to 15.8		
Carthage Island	207.13	3.61					1.7 to 7.1		No obstruction.
Natural pool	207.67	0.73					6 to 12.6		
Goodall's Island	208.40	1.41					1.1 to 1.72		Do.
Natural pool	209.81	0.70					2.9 to 17.9		
Oberton's Towhead	210.51	0.38					0.5 to 5.4		Short gravel-bar.
Natural pool	210.89	2.10					1.4 to 17.6		
Rowland's Towhead	212.99	0.76					0.8 to 6.3		Fair channel.
Natural pool	213.75	2.29					3.6 to 23.4		
Cage's Island	216.04	0.45					3.9 to 9.1		No obstruction,
Natural pool	216.49	0.87					1.4 to 16.4		
Willow Island	217.36	0.25					2.9 to 11.7		Do.
Natural pool	217.61	0.34					4.0 to 32.9		
Hanging Rock Island	217.95	0.76					1.4 to 8.7		Good water; sudden bend to the left to avoid rock.
Natural pool	218.71	0.22					1.8 to 19.2		
Bartlett's Island	218.93	0.30	3.048	5.16	1.266 in 275	24.20	0.9 to 11.7		Rocky reefs in steamboat channel.
Natural pool	219.59	1.06					5 to 42.4		
Parker's Island	220.54	0.21					1.8 to 7.1		No obstruction.
Natural pool	221.49	1.74					0.7 to 32.9		

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Plunkett's Creek	221.2.1	0.05					1.9 to 3.7		Do.
Natural pool	223.28	1.41					3.5 to 20.4		
Rome Island	224.69	0.34					3.7 to 11.5		Do.
Natural pool	225.03	2.88					0.7 to 15		
Campbell's Island	227.91	0.01					1.7 to 7.7		Do.
Natural pool	228.59	2.73					1.0 to 19.4		
Dixon's Island	231.25	0.58					2.9 to 6.4		No obstruction; channel crosses to left.
Natural pool	231.83	1.33					3.4 to 19.4		
Cotton's Bar, Upper Island	233.16	0.35					1.8 to 5.3		No obstruction.
Cotton's Bar natural pool	233.51	0.73					1.8 to 4.3		Do.
Cotton's Bar, Middle Island	234.24	0.23					1.6 to 8.6		Do.
Cotton's Bar natural pool	234.47	0.60					3.4 to 9.4		Do.
Cotton's Bar, Lower Island	235.07	0.29					1.1 to 4.1		Do.
Natural pool	235.36	0.77					3.2 to 30.9		
Goose Creek	236.13	0.70					1.1 to 7.4		Slight obstruction.
Natural pool	236.83	0.40					0.7 to 5.1		Do.
Hartsville Bar	237.23	0.19					2.4 to 7.4		Do.
Natural pool	237.42	2.07					3.0 to 26.9		Do.
Hartsville Island	239.49	0.51					4.5 to 6.5		Do.
Natural pool	240.00	2.65					0.9 to 23.1		Do.
White's Bar	242.65	0.25					3.4 to 6.5		Do.
Natural pool	242.9	1.72					1.4 to 15.9		Do.
Mill's Island	244.62	0.30					2.9 to 10.9		Do.
Natural pool	244.92	1.25					2.9 to 12.4		Do.
Second Creek Island	246.17	0.82					2.1 to 9.8		Do.
Natural pool	246.99	0.85					5.0 to 39.9		Do.
Whiteley's Rock Island	247.84	0.53					0.7 to 6.2		Ripple at head of channel.
Natural pool	248.37	0.79					1.4 to 26.4		
Burdine's Island	249.16	0.59					0.7 to 11.0		Ripple at head.
Natural pool	249.75	0.17					3.6 to 12.4		
Samson Shoal	249.92	0.65					1.4 to 5.3		Slight obstruction.
Natural pool	250.57	1.34					3.8 to 29.4		Do.
Cedar Creek Towhead	251.91	0.99					1.4 to 7.3		Do.
Natural pool	252.90	2.25					3,044.4		Do.
Rocky Creek or Buzzard Island	225.15	0.78					2.5 to 9.0		Do.
Natural pool	255.93	5.36					1.4 to 25.4		Do.
Belote's Bar	261.29	0.98					1.1 to 7.0		Do.
Natural pool	262.27	1.23					2.6 to 19.4		Do.
Spring Creek Bar	263.50	0.26					1.7 to 9.2		Do.
Natural pool	263.76	1.64					2.7 to 25.9		Do.
Big Timber Island	265.4	1.13					1.2 to 8.4		Do.
Natural pool	266.53	0.68					6.8 to 24.4		Do.
Bledsoe's Bar	267.21	0.33					1.3 to 4.4		Do.
Natural pool	268.65	0.54					13.3 to 19.4		Do.
Bledsoe's Island	268.08	0.57					1.7 to 8.3		Do.
Natural pool	268.65	0.97					2.0 to 23.4		Do.
Cairo Island	269.62	0.43					4.2 to 8.6		Do.
Natural pool	270.05	4.63					2.3 to 36.4		Do.
Double Island	274.68	1.34					1.4 to 8.7		Do.
Natural pool									Do.
Gallatin Island	277.63	0.38					2.0 to 5.7		Slight obstruction.
Natural pool	278.01	6.93					0.5 to 35.9		Do.

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Table giving the facts obtained by the survey of the second division, &c.—Continued.

Locality between Point Burnside and Nashville.	Distance from Point Burnside.	Length of each shoal and pool in succession.	Descent of the river.				Depth of low water.	Difference of level from Point Burnside.	Remarks.
			Fall of each shoal and pool.		Maximum fall in a given distance.				
			Total.	Average per mile.	Feet fall and distance.	Corresponding rate per mile.			
	Miles.	*Miles.*	*Feet.*	*Feet.*	*Feet. Distance.*	*Feet.*	*Feet.*	*Feet.*	
Cooper's Island	284.94	0.43					7.1 to 11.1		Ripple at head.
Natural pool	285.36	4.38					3.2 to 17.9		
Lindsay's Island	289.64	0.82	3.324	4.05	0.998 in 370	14.25	1.7 to 5.2		Rock and gravel.
Natural pool	290.46	5.48					0.9 to 13.4		No serious obstruction.
Jones's Island	295.94	1.69					0.9 to 8.9		Do.
Natural pool	297.63	3.77					1.5 to 12.4		Do.
Mancoe Island	301.40	0.51					1.0 to 5.9		Do.
Natural pool	301.91	3.82					2.0 to 13.4		Do.
Hill's Island	305.73	0.89					0.9 to 5.4		Do.
Natural pool	306.62	1.13					2.4 to 11.0		Do.
Donelson's Horse-ford	307.75	0.92	3.046	3.283	0.534 in 300	9.40	0.9 to 6.1		Gravel and dam.
Natural pool	308.67	1.12					1.3 to 5.4		
Martin's Ripple	309.79						0.5 to 1.7		Narrow rock-ledge. No serious obstruction.
Natural pool		0.86							
Beck's Ripple	314.18	5.18					0.7 to 6.1		Short gravel-bar.
Natural pool	315.04						2.0 to 13.9		
Preastley's Shoal	320.22	0.38					1.1 to 3.0		
Upper Nashville Island	323.63	0.76					1.1 to 8.4		Short dam and dredging.
Natural pool	324.39	2.32					1.6 to 10.1		
Nashville	326.71						1.6 to 10.1	232.0	

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The method which I would recommend for improving this portion is the same as for the lower river. That is to excavate the bars and rock ledges to get an additional depth of water; to contract the water-way in places to get the requisite depth; to remove snags and bowlders from the main channel, and to restrain tributary streams in well-determined channels at their junction with the river. It would probably increase the depth of water in the lower stages from 8 inches to about 3 feet.

The probable cost of this method of improvement is given in detail in the following table, in which the first division is divided into two sections and the second division into nine, for the purpose of bringing the practical execution of the work within the means of practical business men.

Localities of proposed improvements from Laurel River to Nashville.

Locality.	Cubic yards of dam at $2 per yard.	Cubic yards of rock excavation at $3 per yard.	Cubic yards of dredging at 75 cts. per yard.	Snags, logs, and trees, by the job.	Cost of work at each locality.	Aggregate by sections, and the total.
Division No. 1.						
Sec. 1. From Laurel River to Smith Shoals	.....	2,000	.....	.....	$6,000	
Smith Shoals, Shadowen Shoal	.....	1,000	.....	.....	3,000	
Smith Shoals, White Cliff Ripple	500	2,000	.....	.....	7,000	
						$16,000
Sec. 2. Smith Shoals, Long Shoals	2,500	2,500	.....	.....	12,500	
Smith Shoals, Short Shoal	2,500	2,500	.....	.....	12,500	
						25,000
Division No. 2.						
Sec. 1. From South Fork to Fishing Creek	.....	.....	.....	400	400	
Near and at Forbush Bar	7,000	340	.....	.....	15,020	
						15,420
Sec. 2. From Gan's Island to Harmon's Shoal	6,000	500	.....	500	14,000	
Wolf or Lilly Island	3,000	1,000	1,000	.....	9,750	
Belk's Island	600	400	.....	.....	2,400	
Belk's Island to Wild Goose Shoal	.....	.....	.....	200	200	
						26,350
Sec. 3. Wild Goose Shoal	2,666	5,883	600	.....	23,431	
Poplar Mountain Creek	.....	500	400	.....	1,800	
Long Bottom Shoal and Island	.....	.....	400	.....	300	
Black Fish Bar	.....	.....	400	.....	300	
Mettie Miller Rock	.....	60	.....	.....	180	
Campbell's Island	.....	.....	600	200	650	
Snow Island	.....	.....	600	100	550	
Self Shoal	.....	.....	400	.....	300	
Crocus Creek Bar	.....	.....	600	100	550	
Bakerton Bar	.....	.....	1,000	100	850	
Rennix and Short Bar	.....	.....	1,000	.....	750	
						29,661
Sec. 4. Walton's Shoals	1,000	.....	4,000	.....	5,000	
Champ Shoals	.....	400	.....	.....	1,200	
Wilbur Island	400	400	2,000	.....	3,500	
Cloyd's Island	.....	.....	.....	200	900	
Mud Camp Bar	.....	.....	600	.....	450	
Stallcup's Island	.....	.....	300	.....	225	
Bickerstaff's Bar	.....	.....	400	.....	300	
Richardson's Upper and Lower Ripple	.....	200	100	.....	675	
Simms's Shoal	.....	100	.....	.....	300	
Shut-in Shoal	.....	2,000	1,000	.....	675	
Celina Bar	.....	.....	1,000	500	1,250	
Turkey Creek Island	500	.....	600	200	1,650	
						21,500
Sec. 5. Brimstone Island	4,200	.....	3,000	.....	10,650	
Kirkpatrick's Bar	.....	200	.....	.....	600	
Scantlin Island	2,600	1,400	6,000	.....	13,900	
						25,150
Sec. 6. Simpson's Island	1,000	500	6,000	200	8,200	
Cub Creek	3,000	400	5,000	.....	10,950	
						19,150
Sec. 7. Holliman Island	1,000	200	5,000	.....	6,350	
Indian Creek	400	600	10,000	500	10,600	
						16,950
Sec. 8. Sand Shoals	3,000	5,000	1,000	.....	21,750	21,750
Sec. 9. Bartlett's Bar	2,000	.....	4,000	200	7,200	
Lindsay's Island	.....	800	400	.....	2,700	
Donelson's Horse-ford	1,000	.....	4,000	.....	5,000	
Upper Nashville Island	1,000	.....	2,000	.....	3,500	
						18,400
Total	45,886	30,883	63,400	3,400	.....	235,331

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The estimated cost of the work is, therefore, $235,331, to which there should be added 10 per cent. ($23,533.10) for superintendence. This would make the total cost $258,864.10. This sum could be profitably expended in two working seasons, and I therefore recommend that the sum of $130,000 be appropriated for this work for the fiscal year ending June 30, 1873.

From the statements of productive capacity and mineral wealth of the country through which this portion of the river flows, given in my last year's report, the necessity of this improvement will be seen. In consequence of the great difficulty of building railroads to the greater part of the upper river, it must be for many years the principal outlet for the produce of a large part of Kentucky and Tennessee, and these facts would really necessitate the more radical improvement by means of locks and dams. But this method would cost about $4,000,000, and as there seems to be no hope that such a sum could be at present appropriated I have thought it proper not to recommend it.

The drawings to illustrate this report are in course of preparation, and will be transmitted as soon as they are completed.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

L 8.

SURVEY OF THE WABASH RIVER.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, January 4, 1872.

GENERAL: I have the honor to submit the following report on the survey of the Wabash River.

The field-work of the survey was begun on the 2d day of last May, and completed during the month of September, under the immediate charge of Mr. F. Stein, civil engineer, who made the reconnaissance of the river last year. The result of this survey is, that there are twelve points on the river, from its mouth to La Fayette, that require special improvement, and that the whole river needs a general improvement by means of light-draught dredges and snag-boats.

The names of the twelve points above referred to, with approximate distances from the mouth of the river, are as follows, viz:

	Miles.
Little Chain	25
Grand Chain	31
Warwick's Ripple	37
Tow-heads, below New Harmony, Indiana	43
New Harmony Cut-off	48
Coffee Island Chute	87
White River Shoals	93
Grand Rapids	95
Little Rock	99
Nine-mile Ripple	111
Horse-shoe Bend	160
Swan Island	175

LITTLE CHAIN.

At this point the river is obstructed during about 4,000 feet of its length by a bed of flat limestone rocks. The river has made a natural

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cut-off, commencing a short distance above this obstruction, and ending about one mile and a half below it.

This cut-off will, in a short time, be the main channel, and it is considered the best mode of improvement here to consider it so, and improve it by correcting its course, clearing it of the drift accumulated in it and dredging it. The estimated cost of this will be as follows:

Removing snags and dredging	$3,000 00
Excavating 47,375+ cubic yards of earth, at 25 cents	11,842 81
Excavating 96,166+ cubic yards of earth, at 50 cents	48,083 05
Total	62,925 86

GRAND CHAIN.

The obstruction consists of rocks in the main channel, over which the water falls 3½ feet in 700 feet in length. The remainder of the river-bed at this point is limestone, and the water over it is very shallow. The improvement proposed here is to excavate a new channel to the depth of 4 feet through the shallow portion of the bed. The estimated cost of this improvement is 22,837+ cubic yards of rock excavation, at $1.25 per cubic yard, $28,546.70.

WARWICK'S RIPPLE.

Here the river is very shallow for a distance of 350 feet. The improvement proposed here is to excavate a channel 100 feet wide and 2 feet deep. The estimated cost of this is, 8,640 cubic yards of excavation, at 30 cents per cubic yard, $2,592.

TOW-HEADS, BELOW NEW HARMONY, INDIANA.

The channel about five miles below New Harmony, Indiana, is obstructed by two small tow-heads, or rather heaps of drift-wood and sand, grown over with young willows and cottonwood. The estimated cost of their removal is as follows, viz: 2,963 cubic yards of excavation, at 75 cents per cubic yard, $2,222.25.

NEW HARMONY CUT-OFF.

Just below New Harmony, Indiana, there is a natural cut-off, which was afterward improved and used as a mill-race, but is now abandoned. This cut-off deprives the main channel of the river, where, for a distance of twelve miles it borders some of the most productive lands in Illinois, of a considerable volume of water, and thus reduces its depth. The improvement proposed here is to close up this cut-off with a dam placed at a suitable point about half a mile below its head. Its estimated cost is as follows, viz:

4 acres of land, at $25 per acre	$100 00
4,456+ cubic yards of dam, at 75 cents per cubic yard	6,342 25
Total	6,442 25

COFFEE ISLAND CHUTE.

Here the river is very shallow, and its bed composed of rock. The improvement proposed consists in deepening the bed of the river, and repairing an old wing-dam of riprap at the head of the island. The estimated cost is as follows:

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11,072¼ cubic yards rock excavation, at $1.25 per cubic yard	$13,840 62
343 cubic yards of riprap, at $2 per cubic yard	686 00
Total	14,526 62

WHITE RIVER SHOALS.

Just below the mouth of the White River the river is very shallow, on account of a ledge of limestone, which breaks in layers of from 3 to 8 inches. The improvement here consists in cutting a channel through the ledge of limestone. The estimated cost is as follows, viz: 3,120+ cubic yards of rock excavation, at $1.25 per cubic yard, $3,901.03.

GRAND RAPIDS.

About two miles above the mouth of White River is the most serious obstruction on the Wabash River. It is known as Grand Rapids. The river here falls about 10 feet in a distance of 700 feet. To overcome this obstruction, a lock and dam were built here by private enterprise about thirty years ago; but both are now almost totally useless. The dam is so severely injured that it needs repairs and additions, and an entirely new lock should be built. The estimated cost of this improvement is:

917+ cubic yards of excavation, for foundation, at $1.50 per cubic yard	$1,376 32
1,261 cubic yards of foundation, at $8 per cubic yard	10,091 20
8,000 cubic yards of wall-masonry, at $10 per cubic yard	80,000 00
Two sets of gates, with machinery, &c	15,000 00
Removing old locks	3,532 48
Repairing dam	25,000 00
Total	135,000 00

LITTLE ROCK.

This is an obstruction in the bed of the river, about four miles above Grand Rapids. It can be removed by blasting, at an estimated expense of $500.

NINE-MILE RIPPLE.

About nine miles below Vincennes, Indiana, the river is obstructed by a bar of loose stones and gravel, the removal of which is estimated to cost as follows, viz: 3,700 cubic yards of excavation, at 75 cents per cubic yard, $2,775.

HORSE-SHOE BEND.

About forty miles above Vincennes the river is obstructed by a bar of gravel and sand, through which it is proposed to excavate a channel, at an estimated cost as follows: 3,703+ cubic yards of excavation, at $1.25 per cubic yard, $4,629.12.

SWAN ISLAND.

About fifty-five miles above Vincennes the river is obstructed by an island or bar, through which a new channel must be excavated, at an estimated cost as follows: 4,629+ cubic yards of excavation, at $1.25 per cubic yard, $5,787.02.

It is believed that the necessary dredging and removal of snags and drift-wood from the channel of the river could be accomplished by two light-draught dredge-boats, each accompanied by a light-draught boat provided with snagging arrangements, and that the river, from La Fayette to its mouth, could thus be cleared in about four months.

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These boats can probably be obtained at about $30 per day each. The cost of this part of the improvement would then be:

Two dredge-boats, 120 days, at $30 per day each	$7,200
Two snag-boats, 120 days, at $30 per day each	7,200
Total	14,400

The total cost of improving the river from La Fayette to its mouth, as herein estimated, would therefore be as follows:

Little Chain	$62,925 86
Grand Chain	28,546 70
Warwick's Ripple	2,592 00
Tow-heads below New Harmony	2,222 25
New Harmony Cut-off	6,442 24
Coffee Island Chute	14,526 62
White River Shoals	3,901 03
Grand Rapids	135,000 00
Little Rock	500 00
Nine-mile Ripple	2,775 00
Horse-shoe Bend	4,629 12
Swan Island	5,787 02
Dredging and snagging	14,400 00
	284,247 84
Add 10 per cent. for superintendence and contingencies	28,424 78
Total cost	312,672 62

This amount could be profitably expended in about two seasons, and I therefore recommend that the sum of $175,000 be appropriated for the improvement of this river for the fiscal year ending June 30, 1873.

To explain the benefit that the improvement of this river would be to the commerce and navigation of the Mississippi River, and all of its tributaries, I beg to submit the following extract from my report dated January 20, 1871, on this same subject.

The Wabash with its branches drains the larger portion of the State of Indiana, a portion of the State of Ohio, and quite a large portion of the State of Illinois. It flows in a southwesterly direction through the northern portion of Indiana, strikes the boundary-line between the two great States of Indiana and Illinois a short distance below Terre Haute, Indiana, then for nearly two hundred miles of its course it forms the boundary between these two States, and empties into the Ohio River about one hundred and thirty miles above the mouth of the latter. It is the most important northern branch of the Ohio River. Below its mouth the Ohio River contains but few obstructions to navigation, and these will probably soon be removed. The three cities, La Fayette, Terre Haute, and Vincennes, are situated on this river.

Twenty years ago the annual value of the commerce of this river and its branches, in wheat, corn, pork, and live stock alone, amounted to about $4,000,000. Since then, and especially within the last few years, iron and coal veins have been opened.

Now, all of this commerce has been nearly entirely ruined by the obstructions in the river. A lock at the Grand Rapids, and a few improvements at other points, were made by private enterprise. But none of these improvements were of a substantial character, and are consequently now in decay.

Now, if this river could be improved only as far up as La Fayette, Indiana, not only would its former commerce return, but it would steadily increase by the development of the mineral resources adjacent to it, and by the continued increase of the population. The soil adjacent to this river is of the most productive kind.

The drawings to illustrate this report need some amendment and to be copied. They will be transmitted as soon as possible.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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APPENDIX M.

ANNUAL REPORT OF MAJOR WALTER McFARLAND, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tennessee, October 1, 1872.

SIR: I have the honor to submit herewith my annual report upon the works of improvement in my charge, for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

M 1.

IMPROVEMENT AND SURVEY OF THE TENNESSEE RIVER.

The progress of this improvement has been extremely unsatisfactory, owing to the utter failure of the contractor, Mr. J. H. Dennis, of Louisville, Kentucky, to keep a respectable force at work upon it.

The correspondence on file in the office of the Chief of Engineers shows that all the contracts which have been made since 1868, for the improvement of the Tennessee River below Chattanooga, were at the beginning of the past fiscal year in the hands of Mr. Dennis. Those contracts were as follows, viz:

1. One dated September 24, 1868, with Charles J. DeGraw, for work at Ross's Tow-head, Burrough's Bar, Tumbling Shoals, and Kelly's Shoals, work to be completed by September 30, 1869. This contract, with the consent of all parties and with the approval of the War Department, was assigned to and accepted by Mr. J. H. Dennis, on the 17th of June, 1869. Subsequently it was modified by restricting the work to be done under it, to Ross's Towhead and Tumbling Shoals.

2. One with J. H. Dennis, dated October 31, 1868, for work at The Suck, Boiling Pot, Seven-mile Island, Buck Island, and Colbert Shoals, to Bee Tree Shoals, inclusive, to be completed by January 1, 1870.

3. One with J. H. Dennis, dated October 20, 1870, with supplement, dated February 1, 1871, for additional work at Ross's Towhead, the Boiling Pot, Colbert Shoals, and Bee Tree Shoals; the work at Colbert Shoals and Bee Tree Shoals to be completed before the end of the low-water season of 1870, and the remainder before the end of the low-water season of 1871.

The first two contracts were made under allotments as follows:

In 1868	$85,000
In 1869	40,500
	125,500
And the third, under that part of the appropriation of 1870, which was allotted to the lower river, viz	45,000
Total	170,500

The first contract not being completed at the time agreed upon, Sep-

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tember 30, 1869, Mr. Dennis applied for and received an extension of time to January 1, 1871.

The second contract not being completed at the time agreed upon, January 1, 1870, was also, upon Mr. Dennis's application, extended to January 1, 1871.

During this period, that is, to the close of the year 1869, the value of the entire amount of work done by Mr. Dennis, under his contracts, was but $45,393.55, out of the $125,500, which had been allotted.

The third contract provided for the completion of the work at Colbert Shoals and Bee Tree Shoals by the end of the low-water season of 1870, but at the close of the year 1870, neither the first two contracts, nor this portion of the third, had yet been completed, and Mr. Dennis again applied for and received an extension of the time of all three of them to the close of the year 1871.

During this year, 1870, the value of the total amount of work done by Mr. Dennis, under his contracts, was but $36,445.30; which, taken with the preceding year's work, amounted to but $81,838.85 out of the $170,500, which had been allotted and appropriated for the work, which he had contracted to do.

During the year 1871, the total value of the work done by Mr. Dennis, under his contracts, was but $23,385.72; none of his contracts were completed and he again applied for an extension of time.

In view of the circumstances of the case, viz, that he had never been able to complete any of the contracts which he had entered into, that out of the amount of work which he should have done in 1869, he had done only a little over one-third, and out of that which he should have finished at the end of 1870 he had done less than one-half, and that with each successive extension of time which he had been allowed for the completion of his contracts, the amount of work which he had actually done had fallen off from 20 to 30 per cent. annually, *i. e.*, $9,000 and $13,000, it became apparent that it would be useless to grant him any further extension of time, unless he could give such guarantees as would insure the completion of his contracts by the close of the year 1872, and I so informed the Engineer Bureau.

By letter, dated March 22, 1872, from the office of the Chief of Engineers, I was authorized to extend Mr. Dennis's contracts, requiring, however, such security as in my judgment would be sufficient to protect the public interest, and I was informed at the same time that I was held responsible for the execution of the work in accordance with approved plans, and that the matter must be left to my judgment.

I accordingly proposed to Mr. Dennis the conditions on which alone, in my judgment, the public interest could be protected in any further extension of his contracts. These conditions he refused to accept, and I therefore notified him by letter, dated April 20, 1872, that his contracts were terminated, the retained percentage forfeited to the United States, and that he would be no longer recognized as having any official connection with the improvement of the Tennessee River. Copies of the conditions proposed, of my letter notifying Mr. Dennis of the termination of his contracts, and of other correspondence relating to the matter, were transmitted to your office April 20, 1872.

The value of the entire amount of work done by Mr. Dennis, under his contracts in the improvement of the Tennessee River below Chattanooga, is	$105,224 57
Amount actually paid him	85,994 78
Amount of percentage retained	19,229 79

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A large part of the appropriations being exhausted, and all the work which the contractor had undertaken to do being left in a ragged and unfinished condition, it will probably take all this forfeited percentage to make good the damage which the United States have suffered by his failure to complete his contracts.

The work so abandoned by the contractor was immediately re-advertised, but in response only one bid was received, May 29, and although this bid could not be regarded as extravagant, I recommended, May 31, that it be rejected, believing that the work could be done better and more cheaply by hired labor.

On the 1st of July I was informed that my recommendation had been approved, and I was directed to carry on the work by "hired labor to the extent of the balance of the appropriation available therefor, including the forfeited percentage."

Since the close of the fiscal year a large amount of work has been done, under this system, at Colbert Shoals.

No work whatever has been done at the Suck or at the Pot, where the *débris* left by the contractor is still in the way, and requires removal. At Ross's Towhead and Tumbling Shoals, no work whatever has been done, although it was laid out for the contractor, and although the original contract required their completion September 30, 1869, three years ago.

The survey of the Muscle Shoals, begun in June, 1871, with the view of ascertaining the probable cost of opening them to navigation, was completed in September of the same year. The result was mapped, and the maps, with the report and the estimated cost of constructing a steamboat canal from Brown's Ferry to Florence, were transmitted to Washington under date of March 23, 1872.

The estimated cost of such a canal, with a trunk 100 feet wide at the water surface, 6 feet depth of water over the miter-sills, and lock-chambers 300 feet long and 60 feet wide, is $3,676,000.

Of the Upper Tennessee, a minute examination has been made from Chattanooga to Kingston, and from Kingston to Knoxville, with a view to ascertaining the cost of giving it 3 feet depth over the bars. The reports of Captain L. C. Overman, Corps of Engineers, who made these examinations personally, bear date respectively August 9, 1871, and December 29, 1871, and have been transmitted to Washington.

Of the $80,000 appropriated for the improvement of the Tennessee River in 1870, $35,000, under the act of March 3, 1871, was set aside for application to the improvement of the river above Chattanooga.

Under this appropriation proposals were called for by advertisement dated July 10, 1871, for improvements at Caney Creek Shoals, Turner's Bar, Half-Moon Shoals, White's Creek Shoals, Watts's Bar, Kelley's Shoals, and Sandy Shoals, all lying between Chattanooga and Kingston. But two bids, opened August 21, were received, and these were so high that I recommended their rejection; which recommendation was approved, and I was directed by letter of August 26 to re-advertise the work, which was accordingly done under date of August 30. The bids were opened October 9, and Albert Blaisdell, of Haverhill, Massachusetts, proving the lowest bidder, I was authorized by letter of October 27 to enter into contract with him to the extent of the amount appropriated for the Upper Tennessee, $35,000; and on the 10th of November this was accomplished.

In January, 1872, this contractor began operations at White's Creek Shoals, and continued, although not with a proper degree of vigor, until

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August, when he quietly absconded, swindling all his workmen and many other creditors out of their pay.

Since that date, under the authority given by indorsement dated August 23, 1871, upon my communication of August 19, 1871, (1624, R and H, 1871,) and also by letter from office of the Chief of Engineers, dated August 26, 1871, (1646, R and H, 1871,) I have employed a large force of hired men to remove the obstructions in the Tennessee, between Chattanooga and Kingston. All the work now doing in the improvement of the Tennessee, both above and below Chattanooga, is done by hired labor, and the progress is certain and satisfactory.

There are two good reasons why this system is far better than the contract system. In the first place, where contractors are paid by the cubic yard for the removal of rock, it is scarcely possible even for the most careful inspector to make an exact measurement, and where there is a doubt, the contractor commonly and properly receives the benefit of it. In the second place, the chances of accident from the sudden and unexpected rises of these western and southern rivers make it necessary that contractors should, in order to secure themselves, bid high. If the possible contingency occur, they are safe, though certain to apply to Congress for relief. If it do not occur, their profits are enormous. The General Government, in matters of insurance, insists on being its own insurer. Why not, in matters of work, do its own work? This, of course, means harder work for the officer who is responsible for its execution; but it means also a better school for his assistants, and makes it certain that a work of improvement will be executed as rapidly as the appropriation for it will admit, and with a fixed view to the interest of the whole community interested in it rather than to that of any one individual.

The condition of the appropriations for the improvement of the Tennessee River is as follows, viz:

Allotted in 1868		$85,000 00
Allotted in 1869		40,500 00
Appropriated in 1870		80,000 00
		205,500 00
Expended during the fiscal year ending June 30, 1869	$15,239 69	
Expended during the fiscal year ending June 30, 1870	47,429 40	
Expended during the fiscal year ending June 30, 1871	36,149 86	
Withheld for internal revenue taxes	500 00	
		99,318 95
Total available June 30, 1871, which includes the forfeited percentage, and of which $60,000 were still undrawn from the Treasury		106,181 05
Expended during the year		21,274 42
Available June 30, 1872		84,906 63

To which must be added the amount of the appropriations made for this river by the act approved June 10, 1872, viz: $25,000 for the improvement of the Tennessee River between Knoxville and Chattanooga, and $50,000 for the continuation of the work in progress on the Tennessee River below Chattanooga, including the Muscle Shoals.

But for the failure of the contractors to perform their work, this entire amount, excepting the two items last appropriated, would have been expended by the close of the fiscal year, and the navigation of the river would have been greatly improved. Under the system of hired labor, much better progress is expected for the coming year.

The following amounts, in addition to those already available, may be

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profitably expended in the improvement of the Tennessee River during the fiscal year ending June 30, 1873, viz:

For the continuation of the improvements in progress below Chattanooga, including the Muscle Shoals	$530,000 00
For the improvement of the river between Chattanooga and Knoxville	120,000 00
	650,000 00

As stated in my last annual report, the question of opening the Tennessee to navigation has more of a national than of a merely local significance. The only great western river beside the Ohio which reaches the mineral wealth of the Alleghany range, and flowing for hundreds of miles along the spurs of that range, through a country exceptionally rich in coal, iron, and other minerals, it cannot be doubted that had it not been for the obstacle to navigation formed by the Muscle Shoals, a city, the rival of Pittsburgh, would have long since sprung up in the mountains of Eastern Tennessee, to share with her the honors and profits of supplying the South and West with coal, iron, and manufactures.

For five millions of dollars, which sum includes the cost of constructing a steamboat canal around the Muscle Shoals, the Tennessee can be made navigable, at the lowest stage of water, from Knoxville to Paducah—a distance of over seven hundred miles—for vessels drawing 3 feet water.

The nearest port of entry is Louisville, Kentucky. I have been unable to ascertain the amount of revenue collected there. I regret that I am unable to furnish precise information concerning the population, wealth, and resources of the regions likely to be benefited by the completion of the schemes for the improvement of the Tennessee, and for the opening of a line of water communication between the Mississippi River and the Atlantic Ocean by way of the Tennessee River; but I have been unable to get the returns of the last census necessary for this purpose, and the matter must therefore be deferred until my next report is rendered.

SURVEYS.

All the surveys placed in my charge have been completed. They are as follows, viz:

1st. Survey of the Tennessee River from Brown's Ferry to Florence, Alabama. This survey, which covers the obstacle known as the Muscle Shoals, was made with the view of ascertaining the probable cost of connecting the two navigable portions of the Tennessee by the construction of a steamboat canal around these shoals.

My report, transmitted to Washington, March 23, 1872, puts the estimated cost of such a work at $3,676,000.

2d. Survey of the Coosa River, Alabama, from Wetumpka to Greensport. One-half of this survey, viz, From Wetumpka to the bridge of the Selma, Rome and Dalton Railroad, was completed last year, and the remainder, from the same bridge to Greensport, was completed this year.

My report, dated March 23, 1872, based upon the survey of the lower portion, and a reconnaissance of the upper part, put the cost of improving the river between Wetumpka and Greensport, so as to admit of the passage of steamers drawing three feet water, at $2,340,746.75; but the survey of the upper part, since made, shows that this estimate is too small by over $50,000, and the probable cost may therefore be taken at $2,400,000.

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The report of the survey of the upper portion, made by Assistant J. C. Long, is transmitted herewith.

3d. Survey for a canal route from the Tennessee River, at a point near Guntersville, Alabama, to the head-waters of the Coosa and Warrior Rivers.

4th. Survey for a canal route from the Etowah River to the Ocmulgee River, Georgia.

These two surveys were for canal routes, to form links of the proposed line of water communication from the Mississippi River to the Atlantic Ocean, by way of the Tennessee, Coosa, Etowah, Ocmulgee, and Altamaha Rivers, upon which I reported fully in my communication of May 25, 1872.

The former survey was made by Assistant J. C. Long, and the latter by Assistant R. C. McCalla, and their reports were transmitted to Washington along with my own.

5th. Examination of Etowah River, from Rome to Cartersville. Assistant Long, whose report is transmitted herewith, puts the cost of improving this river, so as to admit the passage of steamboats drawing three feet water, at $274,718.

6th. Examination of the Oostenaula River, from Rome to Resaca. Assistant R. C. McCalla, whose report is transmitted herewith, states that $10,000 or $12,000 would probably be sufficient to insure a depth of 3 feet during dry summer weather.

There have been expended during the year in these examinations and surveys the sum of $20,030.90.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

Abstract of contracts entered into during the fiscal year ending June 30, 1872, for the improvement of the Tennessee River.

Date.	Name of contractor.	Names of bondsmen.	Subject of contract.	Amount of contract.
Nov. 10, 1871	Albert Blaisdell, of Haverhill, Massachusetts.	Charles A. Dearborn, Charles W. Marden, both of the town of Greenfield, Rockingham County, New Hamphire. Amount of bond, $20,000.	Rock excavation and construction of riprap dams at Sandy Creek Shoals, Kelley's Shoals, Watts's Bar, White's Creek Shoals, Half Moon Shoals, Shields's Dam, King's Bar, Turner's Bar, and Caney Creek Shoals, all in the Tennessee River between Chattanooga and Kingston.	$35,000

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Abstract of bids for improvement of the Tennessee River, opened at Chattanooga, Tennessee, May 29, 1872.

Name of bidder.	Names of guarantors.	Certified to by—	Points bid upon.	Removal of solid rock.			Removal of detached rock.			Removal of gravel.			Removal of snags.			Construction of rip-rap dam.			Amount total of bid.
				Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Number.	Price.	Amount.	Cubic yards.	Price.	Amount.	
Dull & Williams, Keokuk, Iowa.	A. Hosmer, A. L. Constable, Keokuk, Iowa.	W.C.Stripe, assistant assessor, 1st district, Iowa.	Ross Towhead...	750	$4	$3,000	250	$4 00	$1,000	500	$2 00	$1,000	5	$25	$125	1,500	$3 25	$4,875	$10,000
			Tumbling Shoals.	250	5	1,250	750	4 00	3,000	200	3 00	600	3	50	150	.....	.....	.....	5,000
			The Suck	200	5	1,000	1,500	2 50	3,750	.....	.....	.....	3	50	150	.....	.....	.....	4,900
			Colbert Shoals...	900	4	3,600	500	3 00	1,500	500	2 50	1,250	2	50	100	4,500	3 00	13,500	19,950
			Bee-Tree Shoals.	650	4	2,600	400	3 00	1,200	200	2 50	500	2	50	100	1,500	3 00	4,500	8,900
Total.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	48,750

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Abstract of proposals for the improvement of the Upper Tennessee River, opened at Chattanooga, Tennessee, August 21, 1871.

Name of bidder.	Name of guarantor.	Certified to by—	Points bid upon.	Removal of solid rock.			Removal of loose rock.			Removal of gravel.			Removal of snags.			Construction of riprap.			Total amount of bids.
				Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Number.	Price.	Amount.	Cubic yards.	Price.	Amount.	
No. 1.—F. A. Chapman & Co., Kingston, Tennessee.	J. C. Gillespie and W. Crutchfield, Chattanooga, Tennessee.	R. S. Hendrick, postmaster, Chattanooga, Tennessee.	Sandy Creek..	100	$6 00	$600 00	200	$2 50	$500 00	100	$1 50	$150 00	10	$10 00	$100 00	1,800	$3 00	$5,400 00	$6,750 00
																	2 50	4,500 00	5,850 00
			Kelly's Shoals.	900	6 50	5,850 00	100	3 00	300 00	....	....	....	....	....	....	....	....	....	6,150 00
			Watts's Bar ..	200	7 00	1,400 00	50	3 50	175 00	....	....	....	....	....	....	....	....	....	1,575 00
			White's Creek.	200	8 00	1,600 00	100	3 00	300 00	400	2 50	1,000 00	5	10 00	50 00	1,800	4 00	7,200 00	10,150 00
																	3 50	6,300 00	9,250 00
			Half Moon....	500	7 50	3,750 00	100	3 00	300 00	200	2 00	400 00	20	10 00	200 00	2,100	3 50	7,350 00	12,000 00
																	3 00	6,300 00	10,950 00
			Shields's Dam.	....	....	....	50	3 50	175 00	300	1 50	450 00	....	....	....	1,500	3 50	5,250 00	5,875 00
																	2 50	3,750 00	4,375 00
			King's Bar....	100	5 50	550 00	75	3 00	225 00	....	....	....	5	10 00	50 00	1,800	3 00	5,400 00	6,225 00
																	3 00	5,400 00	6,225 00
			Turner's Bar..	500	6 50	3,250 00	100	3 00	300 00	....	....	....	10	10 00	100 00	....	....	....	3,600 00
			Caney Creek..	500	7 50	3,750 00	100	3 50	350 00	500	1 75	875 00	....	....	....	1,800	4 00	7,200 00	12,175 00
																	3 00	5,400 00	10,375 00
																			64,550 00
Grand total.																			58,400 00
No. 2.—H. P. Green, Chattanooga, Tennessee.	J. C. Gillespie and J. F. Mee, Chattanooga, Tennessee.	W. P. Rathbun, Chattanooga, Tennessee.	Sandy Creek..	100	4 75	475 00	200	2 50	500 00	100	1 50	150 00	10	9 75	97 50	1,800	2 50	4,500 00	5,722 50
			Kelly's Shoals.	900	6 00	5,400 00	100	2 50	250 00	....	....	....	....	....	....	....	....	....	5,650 00
			Watts's Bar...	200	6 50	1,300 00	50	2 50	125 00	....	....	....	....	....	....	....	....	....	1,425 00
			White's Creek.	200	7 00	1,400 00	100	2 50	250 00	400	2 75	1,100 00	5	9 75	48 75	1,800	4 00	7,200 00	9,998 75
			Half Moon....	500	7 00	3,500 00	100	2 75	275 00	200	1 75	350 00	20	9 75	195 00	2,100	3 00	6,300 00	10,620 00
			Shields's Dam.	....	....	....	50	2 50	125 00	300	2 00	600 00	....	....	....	1,500	3 00	4,500 00	5,225 00
			King's Bar....	100	5 00	500 00	75	2 50	187 50	....	....	....	5	9 75	48 75	1,800	2 50	4,500 00	5,236 25
			Turner's Bar..	500	6 00	3,000 00	100	2 50	250 00	....	....	....	10	9 75	97 50	....	....	....	3,347 50
			Caney Creek..	500	7 25	3,625 00	100	3 50	350 00	500	2 00	1,000 00	....	....	....	1,800	3 00	5,400 00	10,375 00
Grand total.																			57,600 00

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Abstract of proposals for improvement of Tennessee River between Chat

Number.	Name and residence of bidders.	Name and residence of guarantors.	By whom certified.	Nature of work bid upon.
1	O. G. Vanderhoof, Knoxville, Knox County, Tennessee.	R. M. McClurg and D. L. Ross, Knoxville, Tennessee.	George W. Ross, assessor 2d district Tennessee.	Removal of solid rock..... Removal of loose rock..... Removal of gravel..... Removal of snags..... Construction of riprap dams..
2	F. A. Chapman, Kingston, Tennessee.	J. B. Weaver and J. C. Gillespie, Chattanooga, Tennessee.	R. S. Kendricks, postmaster Chattanooga, Tennessee.	Removal of solid rock..... Removal of loose rock..... Removal of gravel..... Removal of snags..... Construction of riprap dams..
3	Coker & Green, Chattanooga, Tennessee.	George L. Gillespie and R. L. Watkins, Chattanooga, Tennessee.	W. P. Rathburn, Chatttanooga, Tennessee.	Removal of solid rock..... Removal of loose rock..... Removal of gravel..... Removal of snags..... Construction of riprap dams..
4	Eli Loux & Co., Philadelphia, Pennsylvania.	.....	.....	Removal of solid rock..... Removal of loose rock..... Removal of gravel..... Removal of snags..... Construction of riprap dams.
5	Albert Blaisdell, Haverhill, Massachusetts.	Charles A. Dearborn and Charles W. Marden, Groveland, Essex County, Massachusetts.	Charles G. Savory, assistant U. S. assessor 2d division 5th district Massachusetts.	Removal of solid rock..... Removal of loose rock..... Removal of gravel..... Removal of snags..... Construction of riprap dams
6	Kerr & Meyers, Steubenville, Jefferson County, Ohio.	.....	.....	Removal of solid rock..... Removal of loose rock..... Removal of gravel..... Removal of snags..... Construction of riprap dams.

Bid No. 2.—Received after the rest of the bids were opened.
Bid No. 3.—Received after time and after three bids had been read.
Bid No. 4.—Informal, with no guarantee.
Bid No. 5.—Informal. No copy of instructions or advertisement.
Bid No. 6.—Informal. No guarantee. No copy of instructions or advertisement.

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tanooga and Kingston, opened at Chattanooga, Tennessee, October 9, 1871.

Sandy Creek Shoals.			Kelley's Shoals.			Watts's Bar.			White Creek Shoals.			Half-Moon Shoals.		
Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.
100	$6 00	$600 00	900	$6 00	$5, 400 00	200	$6 00	$1, 200 00	200	$6 00	$1, 200 00	500	$6 00	$3, 000 00
200	2 50	500 00	100	2 50	250 00	50	2 50	125 00	100	2 50	250 00	100	2 50	250 00
100	1 40	140 00	.....	.....	.....	.....	.....	.....	400	1 40	560 00	200	1 40	280 00
10	10 00	100 00	.....	.....	.....	.....	.....	.....	5	10 00	50 00	20	10 00	200 00
1, 800	2 60	4, 680 00	.....	.....	.....	.....	.....	.....	1, 800	2 60	4, 680 00	2, 100	2 60	5, 460 00
100	5 00	500 00	900	5 00	4, 500 00	200	5 00	1, 000 00	200	5 25	1, 050 00	500	5 00	2, 500 00
200	2 00	400 00	100	2 25	225 00	50	2 00	100 00	100	2 50	250 00	100	2 00	200 00
100	1 50	150 00	.....	.....	.....	.....	.....	.....	400	2 00	800 00	200	2 00	400 00
10	10 00	100 00	.....	.....	.....	.....	.....	.....	5	10 00	50 00	20	10 00	200 00
1, 800	2 50	4, 500 00	.....	.....	.....	.....	.....	.....	1, 800	3 00	5, 400 00	2, 100	2 50	5, 250 00
100	3 50	350 00	900	4 00	3, 600 00	200	4 00	800 00	200	5 00	1, 000 00	500	4 00	2, 000 00
200	2 50	500 00	100	2 50	250 00	50	2 50	125 00	100	2 50	250 00	100	2 50	250 00
100	1 50	150 00	.....	.....	.....	.....	.....	.....	400	1 25	500 00	200	1 50	300 00
10	8 00	80 00	.....	.....	.....	.....	.....	.....	5	8 00	40 00	20	8 00	160 00
1, 800	2 75	4, 950 00	.....	.....	.....	.....	.....	.....	1, 800	3 00	5, 400 00	2, 100	3 00	6, 300 00
100	4 00	400 00	900	4 00	3, 600 00	200	4 00	800 00	200	4 00	800 00	500	4 00	2, 000 00
200	4 00	800 00	100	4 00	400 00	50	4 00	200 00	100	4 00	400 00	100	4 00	400 00
100	2 50	250 00	.....	.....	.....	.....	.....	.....	400	2 50	1, 000 00	200	2 50	500 00
10	20 00	200 00	.....	.....	.....	.....	.....	.....	5	20 00	100 00	20	20 00	400 00
1, 800	2 50	4, 500 00	.....	.....	.....	.....	.....	.....	1, 800	2 50	4, 500 00	2, 100	2 50	5, 250 00
100	4 00	400 00	900	4 50	4, 050 00	200	4 50	900 00	200	4 00	800 00	500	4 00	2, 000 00
200	2 75	550 00	100	3 75	375 00	50	3 75	187 50	100	2 75	275 00	100	2 75	275 00
100	1 00	100 00	.....	.....	.....	.....	.....	.....	400	1 00	400 00	200	1 00	200 00
10	10 00	100 00	.....	.....	.....	.....	.....	.....	5	10 00	50 00	20	10 00	200 00
1, 800	2 75	4, 950 00	.....	.....	.....	.....	.....	.....	1, 800	2 75	4, 950 00	2, 100	2 75	5, 775 00
100	1 75	175 00	900	1 75	1, 575 00	200	1 75	350 50	200	1 75	350 00	500	1 75	875 00
200	0 95	190 00	100	0 95	95 00	50	0 95	47 50	100	0 95	95 00	100	0 95	95 00
100	0 95	95 00	.....	.....	.....	.....	.....	.....	400	0 95	380 00	200	0 95	190 00
10	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	20	.....	.....
1, 800	1 95	3, 510 00	.....	.....	.....	.....	.....	.....	1, 800	1 95	3, 510 00	2, 100	1 95	4, 095 00

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Abstract of proposals for improvement of

Number.	Name and residence of bidders.	Name and residence of guarantors.	By whom certified.	Nature of work bid upon.
1	O. G. Vanderhoof, Knoxville, Knox County, Tennessee.	R. M. McClurg and D. L. Ross, Knoxville, Tennessee.	George W. Ross, assessor 2d district Tennessee.	Removal of solid rock ..... Removal of loose rock ..... Removal of gravel ..... Removal of snags..... Construction of riprap dams.
2	F. A. Chapman, Kingston, Tennessee.	J B. Weaver and J. C. Gillespie, Chattanooga, Tennessee.	R. S. Kendricks, postmaster Chattanooga, Tennessee.	Removal of solid rock ..... Removal of loose rock ..... Removal of gravel ..... Removal of snags..... Construction of riprap dams.
3	Coker & Green, Chattanooga, Tennessee.	George L. Gillespie, and R. L. Watkins, Chattanooga, Tennessee.	W. P. Rathburn, Chattanooga, Tennessee.	Removal of solid rock ... ... Removal of loose rock ..... Removal of gravel ..... Removal of snags..... Construction of riprap dams.
4	Eli Loux & Co., Philadelphia, Pennsylvania.	.....	.....	Removal of solid rock ... ... Removal of loose rock ..... Removal of gravel ..... Removal of snags..... Construction of riprap dams
5	Albert Blaisdell, Haverhill, Massachusetts.	Charles A. Dearborn and Charles W. Marden, Groveland, Essex County, Massachusetts.	Charles G. Savory, assistant U. S. assessor 2d division 5th district Massachusetts.	Removal of solid rock ... ... Removal of loose rock ..... Removal of gravel ..... Removal of snags..... Construction of riprap dams.
6	Kerr & Meyers, Steubenville, Jefferson County, Ohio.	.....	.....	Removal of solid rock ..... Removal of loose rock ..... Removal of gravel ..... Removal of snags..... Construction of riprap dams

Bid No. 2.—Received after the rest of the bids were opened.
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Tennessee River &c—Continued.

Shields's Dam.			King's Bar.			Turner's Bar.			Caney Creek Shoals.			
Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Cubic yards.	Price.	Amount.	Total of bid.
.....	.....	.....	100	$6 00	$600 00	500	$6 00	$3,000 00	500	$6 00	$3,000 00	$18,000 00
50	$2 50	$125 00	75	2 50	187 50	100	2 50	250 00	100	2 50	250 00	2,187 50
300	1 40	420 00	.....	.....	.....	.....	.....	.....	500	1 40	700 00	2,100 00
.....	.....	.....	5	10 00	50 00	10	10 00	100 00	.....	.....	.....	500 00
1,500	2 60	3,900 00	1,800	2 60	4,680 00	.....	.....	.....	1,800	2 60	4,680 00	28,080 00
												50,867 50
.....	.....	.....	100	5 00	500 00	500	5 00	2,500 00	500	5 25	2,625 00	15,175 00
50	2 00	100 00	75	2 00	150 00	100	2 00	200 00	100	2 00	200 00	1,825 00
300	1 50	450 00	.....	.....	.....	.....	.....	.....	500	1 75	875 00	2,675 00
.....	.....	.....	5	10 00	50 00	10	10 00	100 00	.....	.....	.....	500 00
1,500	3 00	4,500 00	1,800	3 00	5,400 00	.....	.....	.....	1,800	3 00	5,400 00	30,450 00
												50,625 00
.....	.....	.....	100	3 50	350 00	500	4 00	2,000 00	500	4 50	2,250 00	12,350 00
50	2 25	112 50	75	2 50	187 50	100	2 50	250 00	100	2 50	250 00	2,175 00
300	1 25	375 00	.....	.....	.....	.....	.....	.....	500	1 50	750 00	2,075 00
.....	.....	.....	5	8 00	40 00	10	8 00	80 00	.....	.....	.....	400 00
1,500	3 00	4,500 00	1,800	2 75	4,950 00	.....	.....	.....	1,800	3 00	5,400 00	31,500 00
												48,500 00
.....	.....	.....	100	4 00	400 00	500	4 00	2,000 00	500	4 00	2,000 00	12,000 00
50	4 00	200 00	75	4 00	300 00	100	4 00	400 00	100	4 00	400 00	3,500 00
300	2 50	750 00	.....	.....	.....	.....	.....	.....	500	2 50	1,250 00	3,750 00
.....	.....	.....	5	20 00	100 00	10	20 00	200 00	.....	.....	.....	1,000 00
1,500	2 50	3,750 00	1,800	2 50	4,500 00	.....	.....	.....	1,800	2 50	4,500 00	27,000 00
												47,250 00
.....	.....	.....	100	4 00	400 00	500	4 50	2,250 00	500	4 00	2,000 00	12,800 00
50	2 75	137 50	75	2 75	206 25	100	3 75	375 00	100	2 75	275 00	2,656 25
300	1 00	300 00	.....	.....	.....	.....	.....	.....	500	1 00	500 00	1,500 00
.....	.....	.....	5	10 00	50 00	10	10 00	100 00	.....	.....	.....	500 00
1,500	2 75	4,125 00	1,800	2 75	4,950 00	.....	.....	.....	1,800	2 75	4,950 00	29,700 00
												47,156 25
.....	.....	.....	100	1 75	175 00	500	1 75	875 00	500	1 75	875 00	5,250 00
50	0 95	47 50	75	0 95	71 25	100	0 95	95 00	100	0 95	95 00	831 25
300	0 95	285 00	.....	.....	.....	.....	.....	.....	500	0 95	475 00	1,330 00
.....	.....	.....	5	.....	.....	10	.....	.....	.....	.....	.....	.....
1,500	1 95	2,925 00	1,800	1 95	3,510 00	.....	.....	.....	1,800	1 95	3,510 00	21,060 00
												28,471 25

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IMPROVEMENT AND SURVEY OF THE TENNESSEE RIVER.

UNITED STATES ENGINEER OFFICE,
Painesville, Ohio, January 5, 1872.

GENERAL: I have the honor to transmit herewith the report of Captain L. C. Overman, Corps of Engineers, upon the obstructions to navigation in the Tennessee River, between Knoxville, Tennessee, and Kingston, Tennessee, dated December 29, 1871, and supplementary to his report of August 9, 1871, upon the obstructions in the same river between Kingston, Tennessee, and Chattanooga, Tennessee.

His estimates, it will be observed, are for channel-depths of 2½ feet and 3 feet, respectively, at low water, amounting to $75,000 in the one case, and $125,000 in the other.

Inasmuch as the reasons which make a channel-depth of 3 feet desirable between Kingston and Chattanooga, exist also in respect to the river between Kingston and Knoxville, (this part of the valley of the Tennessee quite equaling any other part in richness, population, and enterprise,) I would respectfully recommend that the minimum low-water depth of 3 feet adopted in the improvement of the channel-ways of the other portions of the river both above and below Muscle Shoals be adopted for this portion also, by which means any steamer plying on the Tennessee above Muscle Shoals will be enabled to reach Knoxville as the head of navigation; and thus will the commerce of this important part of the river be enabled to share in all the benefits enjoyed by the lower portions without being hampered by being restricted to the use of the smaller and inferior class of vessels which a less depth of water would render necessary.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tennessee, December 29, 1871.

MAJOR: In compliance with telegraphic instructions dated Washington, D. C., December 19, 1871, I have the honor to submit the following report as the result of an examination of the Holston River between Knoxville and Kingston, Tennessee, with a view to the improvement of the river.

GENERAL CHARACTER OF THE OBSTRUCTIONS.

The obstructions to continuous navigation above Kingston, like those between Kingston and Chattanooga, are "low-water" obstructions. They consist of bars, either of rock or of gravel, extending across the river, with a length varying from one hundred feet to three miles; the depth of water in the channel over these bars varying from fifteen to thirty inches at extreme low water, the current over the bars varying from two and a half to six miles per hour.

Between the shoals the stream is deep, varying from six to thirty feet, and the current not over two and a half miles per hour. The river is thus divided into "pools" and "shoals." The rock in the bed and ledges is limestone, with considerable "dip" to the south, and is "stratified."

FORMER IMPROVEMENTS.

This portion of the river has already been worked upon in former years and with some benefit. The first work was done in 1832, by the State of Tennessee, upon plans

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proposed by Colonel S. H. Long, topographical engineer, United States Army. The second improvement was by act of Congress and under the direction of Colonel J. McClellan, topographical engineer, United States Army, in 1853. The method employed in each case was the same, viz, the construction of wing-dams, the excavation of a small amount of rock and gravel, and the removal of loose rocks, logs, snags, &c., together with the providing of the necessary aids for "warping" the boats through swift water. These improvements were made with a view to the obtaining of a depth of 24 inches of "extreme low water" over all bars. In this they were successful as a rule, since few of the bars now give a less depth than 2 feet at extreme low water. In some places the old dams are much abraded, owing generally to the following defects in construction:

1. Cross-section of dam too small.
2. Fragments of stone used to fill dam with were too small.
3. The timber employed to form dams have rotted away.
4. The axis of the dam in some cases makes too great an angle with current.

PROPOSED GENERAL PLAN FOR IMPROVEMENT.

In view of the facts that during the low-water season the amount of freight to be moved is small, that steamers for this trade are of light draught, and that the trade benefited does not justify large expenditure of public funds, it is proposed to estimate for a channel only 2½ feet deep and 120 feet wide at extreme low-water. To accomplish this it will be necessary in general terms to excavate through the bars, where the expense will be reasonable; to excavate and build dams in other places; to remove all isolated rock and bowlders from the channel; to remove all gravel, sand, snags, &c., which may obstruct the channel at such points as shall best improve the navigation, due regard being had to the most economical plan in each case.

POINTS FOR IMPROVEMENT, WITH DETAILS.

1. KNOXVILLE SHOALS.

These shoals are situated immediately opposite the river front at the town of Knoxville. The obstruction consists of a gravel-bar extending across the river, the river being divided unequally by two small islands, or "tow-heads." The channel is to the right of the islands, midway of the right chute, having a low-water depth of at least 24 inches. A large sand and gravel bar on the right of the channel prevents boats drawing over 12 inches from coming alongside of the shore on the city front.

Former improvements at Knoxville Shoals.—They consist of a dam between the "tow-heads," and a second dam at the head of the upper island, extending to the left bank. These dams are in tolerable repair. To obtain the desired depth it is proposed to enlarge, repair, and extend the present dams, and remove a few loose rocks in the channel.

Estimate for the proposed improvement.—Two hundred cubic yards of riprap dam, and the removal of 50 cubic yards of rock. If it is deemed necessary and proper to remove the bar between the channel and the city front, it will be necessary to construct a new dam about 800 feet long; this dam to start from a point on the left bank, 800 feet above the head of the upper island, and extending obliquely down stream; this dam to act as a "scouring-dam" to cut away the gravel-bank.

Approximate estimate of "scouring-dam."—Two thousand cubic yards of riprap dam.

2. LYON'S SHOALS.

These shoals are situated about seven miles below Knoxville. The obstruction consists of three rock-bars extending across the river. The river is divided into three "chutes" by two islands. The channel is through the right "chute," and has a low-water depth of at least 20 inches. The upper bar is covered with large gravel-stones.

Former improvements at Lyon's Shoals.—They consist of a dam extending across the head of the left chutes, just above the islands and from the left bank, with a "lateral dam" at the end of main dam. Axis of the main dam 70°; axis of the "lateral dam" 0°. The whole dam is about 1,700 feet long. It needs considerable repair.

It is proposed to repair, enlarge, and extend the present dam, and to excavate a small amount of rock from the middle and lower bars.

Approximate estimate for proposed improvement.—The construction of 800 cubic yards of riprap dam; the excavation of 300 cubic yards of rock; the excavation of 200 cubic yards of loose rock and gravel.

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3. Williams Shoals.

These shoals, near a cluster of small islands of the same name, are situated about nine miles below Knoxville. The obstructions consist of a gravel-bar at the head of the islands, a rock-reef midway of the lower island, and a second gravel-bar at the foot of the islands. The channel is near the right bank, from the head to the foot of the islands, then passes obliquely across the river to the left shore. The least depth is 18 inches at extreme low water; average about 22 inches; current runs at the rate of four miles per hour.

Former improvements at Williams Shoals.—They consist of a dam extending from the head of the upper island to the left bank, and a second dam from the middle of the same island to the head of the right-hand island. These dams are badly broken and abraded. It is proposed to enlarge, repair, and extend the old dams, to excavate a small amount of rock from the middle bar, and to remove the loose rock and snags now in the channel-way. It may also be necessary to construct a dam from a point on the right bank, near the foot of the island, to cut out the channel over the lower gravel-bar.

Approximate estimate of quantities for proposed improvement.—The construction of 500 cubic yards of riprap dam, (repair of old dam;) the removal of 250 cubic yards of loose rock and gravel; the excavation of 400 cubic yards of solid rock; and, possibly, the construction of 1,600 yards of new dam.

4. Little River Shoals.

These shoals are situated above the mouth of Little River, and near a group of small islands of the same name. The main channel passes between the large islands on the left bank and a group of small islands near the right bank. The obstructions consist of a rock-bar overlaid with gravel. The bar extends the whole length of the river occupied by the cluster of islands, say one-half mile.

Former improvements at Little River Shoals.—They now consist of a series of dams, cutting off all the chutes to the left of the main or channel chute; of a wing-dam from the island at the head, and on the left of main chute, with a lateral dam, (parallel to the channel;) of a dam and lateral dam on the right side of the main chute, thus throwing all the water into the main chute. The channel now shows a least depth of 18 inches at extreme low water. The current runs very swift, so that the required depth will have to be gained by excavation after the dams are renewed.

Approximate estimate of quantities for proposed improvement.—The excavation of 450 cubic yards of rock; the construction of 1,500 cubic yards of riprap dam; the removal of 100 yards of loose rock.

5. Russell's Shoals.

These shoals are situated about twenty-seven miles below Knoxville, and near an island of the same name. The obstructions consist of a gravel-bar at the head of the island, a rock-reef midway of the island, and a bar extending across the river about one-half mile below the foot of the island. These shoals are over a mile in length. The channel is in the chute to the left of the island, and has a minimum depth of 20—average depth being about 24 inches. Channel near right bank below the island.

Former improvements.—None at present visible. It is possible that some excavation may have been done. It is proposed to construct a dam from the head of the island up stream, and parallel with the channel for a distance of 800 feet, thence by an oblique piece of dam to the right bank, thus cutting off the right chute, and confining all the water to the main chute. It will also be necessary to excavate a channel through the middle bar, and to construct a dam from the left bank above the head of the third shoal to confine and accumulate the water on that shoal.

Approximate estimate of quantities for proposed improvements.—Excavation of 300 yards of rock.

Construction of 2,000 yards at dam, or instead of lower dam excavate 250 cubic yards of rock, which will reduce the number of yards of dam to about 1,200.

6. Chota Island Shoals.

These shoals are about thirty-eight miles below Knoxville, near an island of the same name. The obstructions consist of a number of rocky bars and detached rocks, scattered for the length of a mile. The current is swift and the water rough. The present channel is near the left bank for the greater part of the distance, and has a minimum depth of 20 inches.

Former improvements of Chota Shoals.—They consist of several dams extending from right to the left across the main chute, the uppermost dam serving to close the right chute. The dams are all in bad condition, owing principally to their being at a large

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angle with the current lines. To obtain the increased depth required, it is proposed to repair, enlarge, and strengthen the dams, and to excavate through the reef, and to remove all detached or projecting rocks near the channel. The navigation of this shoal is difficult and hazardous, owing to the swift current and "ragged condition" of the channel-way. The water being rough it confounds the break of the projecting rocks.

Approximate estimate of quantities for the improvement.—The removal of 500 cubic yards of rock; the removal of 200 cubic yards of loose rock; the construction of 1,600 yards of riprap dam.

7. Coulter's Islands Shoals.

These shoals are situated about thirty-nine miles below Knoxville, near two islands, whose name they bear. The obstructions consist of a gravel-bar at the head, and four rock-reefs across the main chute along the length of the two islands, the last reef being below the foot of the lower island. The main channel is down the right chute, and near the right bank, until it reaches the foot of the islands. The minimum depth is 16 inches, the average being over 20 inches.

Former improvements at Coulter's Islands Shoals.—They consist of a dam from the head of the upper island to the left bank, and of a second dam from the head of the second island to the center of the first island. The dams are in very bad repair, and deflect but little water into the main chute. There is but 14 inches on some parts of the upper bar in the main channel. Average depth of bars (minimum) about 18 inches.

It is proposed to rebuild the old dam and to excavate the necessary channel through the rock-reefs, and to remove all detached rocks, snags, &c.

Approximate estimate of quantities for the proposed improvement.—Construction of 600 cubic yards of dam, (riprap;) excavation of 350 cubic yards of rock from reefs; removal of 150 cubic yards of loose rock.

8. Shaw's or Sister Islands Shoals.

These shoals are situated about forty-two miles below Knoxville, near a group of islands known as the Sister Islands. The obstructions consist of a number of narrow reefs or "hog-backs," extending for over a mile and a half of river. The main channel is through the left chute. The water is swift and the channel tortuous. Former improvements, if any, consisted in widening, deepening, and correcting the channel. Least depth at present is 20 inches, generally 24 inches. It is proposed to deepen, widen, and straighten the existing channel through the various reefs, and to remove isolated rocks in the channel-way.

Approximate estimate of quantities for the proposed improvement.—Excavation of 300 yards of rock from reefs; removal of 150 yards of loose rock.

9. Bustle's Bar.

This shoal is situated about forty-five miles below Knoxville. The obstruction consists of a rock-bar partially overlaid with gravel. It extends for over 500 yards down the river. No former improvements. The channel is near the middle of the river. Least water in the channel-way, over the bar, is 22 inches. The required depth ($2\frac{1}{2}$ feet) may be obtained by the removal of a small quantity of gravel and the excavation of a small amount of rock from the ledges.

Approximate estimate of quantities for the proposed improvement.—Excavation of 300 cubic yards of rock; removal of 200 cubic yards of gravel.

10. Bell Canton Shoals.

These shoals are situated about forty-six miles from Knoxville. They are near a cluster of small islands, the channel being on the right "chute," having a low-water depth of 22 inches. No former improvement. The removal of a small quantity of gravel will give the requisite depth across this bar, together with the removal of some snags.

Approximate estimate of quantities for proposed improvement.—Removal of 300 yards of gravel; removal of 5 snags.

11. Lenoir's Shoals.

These shoals are situated at the confluence of the Little Tennessee River with the Holston. A small island divides the river into two chutes. The main channel is near the right bank. Least depth, 18 inches. Former improvements, if any, consisted of excavating the natural channel. It is proposed to construct a dam from a point about 100 yards from the right bank and at the head of the schoal, the dam to extend upstream, making an angle of 45° with the current-lines. This section of the dam will

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be about 600 feet long. A second section, in the form of a lateral dam, will extend down-stream from the foot of the other section. This section will be 300 feet long. This dam, with the removal of a small quantity of rock, it is thought, will give the necessary depth.

Approximate estimate of quantities for proposed improvement.—Excavation of 200 cubic yards of rock; construction of 1,200 cubic yards of riprap dam.

12. Bouder's Shoals.

These shoals are situated near an island of the same name, and about fifty miles below Knoxville. The obstructions consist of two narrow reefs, one near the head, the other at the foot of the small island. The channel is down the right chute about 200 feet from the island. Has a low-water depth of 22 inches. No former improvements, unless it was "excavation." It is proposed to remove the projecting parts of the reef, and thus obtain the requisite depth and width of channel. A dam to close the left chute might also be employed, but it is thought that excavation will be equally economical.

Approximate estimate for proposed improvement.—Excavation of 300 yards of rock; removal of 200 yards of gravel.

13. Loudon Shoals.

These shoals are situated just below the town of Loudon, below the railroad-bridge belonging to the East Tennessee, Virginia and Georgia Railroad Company. The channel is near the left bank, close under a high rock bluff. The obstruction is a rough rocky bar, causing swift and rough water. The channel has an average depth of 30 inches, but it requires the removal of several rocks and projecting ledges to make the passage less difficult.

Approximate estimate of quantities for improvement.—Removal of 200 yards of rock.

14. Harrison's Shoals.

These shoals are situated about one mile below Loudon Shoals, and are of a similar nature to the above. A small island divides the river, the channel being in the chute to the right of the island. The water is swift and rough. It will require the removal of a small quantity of rock to make this channel safe and straight.

Approximate estimate of quantities.—Removal of 200 yards of rock; removal of 5 snags.

15. Sweetwater Shoals.

These shoals are situated about eight miles below London. A small island divides the river, the channel being close to the left bank. The obstruction is a gravel-bar, least depth in channel on this bar being 20 inches. No former improvements, although the steamboat-men have, on different occasions, removed some rocks and snags from the channel. It is proposed to construct a dam from a point on the right bank about 800 feet above the head of the island, extending obliquely across the river and below the head of the island, thus cutting off the water which passes through the right chute, and at the same time deepening the water in the channel. A lateral dam at the end will also be needed to confine the water until it passes the foot of the "tow-head." The entire length of this dam will be about 1,800 feet.

Approximate estimate of quantities for proposed improvement.—Construction of 2,000 yards of riprap dam; removal of 6 snags.

16. Bogart's Shoals.

These shoals are situated about eleven miles below Loudon. The obstructions consist of a number of rock-bars and reefs. The channel is through the right chute, the river being divided by two or three small islands. There is about 24 to 30 inches of water over the obstruction, owing to the former improvements. The trouble now is the rocks in the passage, which make the channel tortuous and difficult. Former improvements consist of crib-dam extending from the right bank with a "lateral dam" at the foot; dam is about 400 yards in length. It is in bad repair. It is proposed to repair and enlarge the old dam; to construct a new dam across the head of the left chute; to close an opening of 100 feet between two islands directly opposite the end of the wing-dam, and to remove a small quantity of rock in order to straighten the channel.

Approximate estimate of quantities for proposed improvement.—Construction of 1,000 yards of dam; removal of 200 yards of rock.

17. Bacon's Shoals.

These shoals are situated about thirteen miles below Loudon. This obstruction is a gravel-bar, the channel being midway of the river; least depth 24 inches at low water. No former improvements, and all that is required is the removal of a small amount of

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gravel and the removal of some detached rocks and snags which now obstruct the channel at the foot of the shoals.

Approximate estimate of quantities for proposed improvement.—Removal of 500 yards of gravel; removal of 60 yards of rock; removal of 4 snags.

18. Wilson's Island Shoals.

These are situated seventeen miles below Loudon, and the obstructions consist of two rock-reefs with detached rocks in the channel. The channel is through the right chute. No former improvements. It is proposed to close the left chute with a dam and excavate the necessary channel through the reef, removing detached rocks.

Approximate estimate of quantities for proposed improvement.—Construction of 600 yards of riprap dam; excavation of 200 yards of rock.

19. Seven-Islands Shoals.

These shoals are situated about nineteen miles below Loudon and near the islands whose name they bear. The low-water channel is through the extreme right "chute." It is quite narrow and much longer than any of the other passages. It has a low-water depth of 3 feet throughout, save at two reefs, which are narrow and may easily be removed or deepened. It is proposed to close all lateral passages leading from this right chute; to excavate a small amount of rock from the reefs, and to remove all snags and impending trees.

Approximate estimate of quantities for proposed improvement.—Construction of 800 cubic yards of dam; removal of 300 cubic yards of rock; removal of snags and trees.

20. Long Island Shoal.

This shoal, situated near the head of Long Island, is about twenty-two miles below Loudon. The low-water channel is near the right bank, and has a minimum depth of 20 inches. No former improvement. It is proposed to construct a dam from the left bank across the head of the island, and extending below the head of the island, thus causing all the water to flow through the right "chute," and confining it to the channel-way. This will also overcome the gravel-bar at the lower end of the island. The island is nearly two miles in length, and the shoal at the lower end is the last of the series between Knoxville and Kingston.

Approximate estimate of quantities for proposed improvement.—Construction of 1,000 yards of riprap dam. The improvement of the various shoals heretofore mentioned will open up to continuous navigation nearly one hundred miles of river navigation through a fertile valley whose mineral resources are well known. The river is the only practicable means of transportation for heavy freight, as the railroad is generally from ten to twenty miles from the river, (save at points where it crosses or meets it,) and the roads leading from the river to the railroad are very rough and hilly, as they necessarily cross high hills and deep valleys. At present boats only navigate the river during about seven months of the year.

It is thought that a channel 2½ feet deep at all seasons will be sufficient for the wants of the trade. To make a deeper channel, say 3 feet, would increase the expense very largely, say 75 per cent.

It is thought the work necessary for the improvement of the river not only above Kingston, but below, could be much more satisfactorily done, and with but slight if any increase of expense by days' labor instead of contract. Much good could be done by the removal of detached rocks at various places which now interfere with the navigation, but which under the contract system would have to wait for the improvement of the shoal or bar near to which they are situated.

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RECAPITULATION.

Approximate quantities and prices for improving the Holston River between Knoxville and Kingston, Tennessee; channel to be 120 feet wide, by 2½ feet deep.

Order.	Shoals requiring improvements.	Riprap dam.			Rock excavation.			Gravel.			Amount total.
		No. cubic yards.	Price.	Amount.	No. cubic yards.	Price.	Amount.	No. cubic yards.	Price.	Amount.	
1	Knoxville Shoals	200	$2 50	$500	50	$4 00	$200				$7[illegible]
2	Lyon's Island Shoals	800	2 50	2,000	300	4 00	1,200	200	$2 00	$400	3,[illegible]
3	Williams Shoals	500	2 50	1,250	400	4 00	1,600	250	2 00	500	3,3[illegible]
4	Little River Shoals	1,500	2 50	3,750	450	4 00	1,800	100	2 00	200	5,7[illegible]
5	Russell's Shoals	2,000	2 50	5,000	300	4 00	1,200				6,2[illegible]
6	Chota Island Shoals	1,600	2 50	4,000	500	4 00	2,000	200	2 00	400	6,4[illegible]
7	Coulter's Isl'd Shoals	600	2 50	1,500	350	4 00	1,400	150	2 00	300	3,2[illegible]
8	Sister Island Shoals				300	4 00	1,200	150	2 00	300	1,5[illegible]
9	Bustle's Bar				300	4 00	1,200	200	2 00	400	1,6[illegible]
10	Bell Canton Shoals							300	2 00	600	[illegible]
11	Lenoir Shoals	1,200	2 50	3,000	200	4 00	800				3,[illegible]
12	Bouder's Shoals				300	4 00	1,200	200	2 00	400	1,6[illegible]
13	Loudon Shoals				200	4 00	800				[illegible]
14	Harrison's Shoals				200	4 00	800				[illegible]
15	Sweetwater Shoals	2,000	2 50	5,000							5,[illegible]
16	Bogart's Shoals	1,000	2 50	2,500	200	4 00	800				3,3[illegible]
17	Bacon's Shoals				60	4 00	240	500	2 00	1,000	1,2[illegible]
18	Wilson's Isl'd Shoal	600	2 50	1,500	200	4 00	800				2,3[illegible]
19	Seven Islands Shoal	800	2 50	2,000	300	4 00	1,200				3,2[illegible]
20	Long Island Shoal	1,000	2 50	2,500							2,5[illegible]
	Total	13,800		34,500	4,610		18,440	2,250		4,500	57,44[illegible]

NOTE.—The above quantities are approximate, but will not overrun. The prices per yard are less on the average, than contract prices for similar work. The above quantities do not include the removal of snags.

Approximate estimate for improvement of the Holston River.—Improvement based upon making a channel 120 feet wide by 2½ feet deep at extreme low water.—Improvement of twenty different shoals.

Excavation of 4,610 cubic yards of rock, at $4	$18,440 [illegible]
Construction of 13,800 cubic yards of riprap dam, at $2.50	34,500 [illegible]
Removal of 2,250 cubic yards of gravel, &c., at $2	4,500 [illegible]
Removal of 100 snags and overhanging trees, at $10	1,000 [illegible]
Total	58,440 [illegible]
Contingencies	1,560 [illegible]
	60,000 [illegible]
Allowing 25 per cent. for superintendence and other contingencies	15,000 [illegible]
	75,000 [illegible]

To make a 3-foot channel would increase the above approximate estimate at least 60 per cent. since other bars would come in, giving $125,000. The above estimates will be found rather under than over the actual cost.

Respectfully submitted.

L. COOPER OVERMAN,
Captain, Corps of Engineers.

Major MCFARLAND,
Corps of Engineers, U. S. A.

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M 3.

RESURVEY OF THE TENNESSEE RIVER FROM BROWN'S FERRY TO FLORENCE, ALABAMA.

UNITED STATES ENGINEER OFFICE,
Painesville, Ohio, March 23, 1872.

GENERAL: I have the honor to transmit herewith my report upon the resurvey of the Tennessee River from Brown's Ferry, Alabama, to Florence, Alabama, made under your instructions, and in compliance with the act of Congress approved February, 1871, relating to surveys.

That portion of the Tennessee River covered by this survey is commonly known as the Muscle Shoals, although three distinct series of shoals, separated by deep water, are included within its limits, viz:

Elk River Shoals, beginning two and one-half miles below Brown's Ferry, and extending to the mouth of the Elk River, eight miles and one-half, with a fall of 21 feet.

Big Muscle Shoals, beginning six miles and one-quarter below Elk River, and extending to Bainbridge (formerly known as Campbell's) Ferry, fourteen miles and one-half, with a fall of 82 feet. It is around this shoal that a canal was constructed in 1832–'37.

Little Muscle Shoals, beginning one mile and one-quarter below the foot of Big Muscle Shoals, and extending to Florence, Alabama, five miles and one-third, with a fall of 22 feet.

Between the foot of Elk River Shoals and the head of Big Muscle Shoals lies the deep water of Lamb's Ferry pool or eddy, six miles and one-quarter in length, with a fall of 5.4 feet and a depth varying from 8 feet to an unknown amount over 12 feet, and with one rocky bar about one mile and three-quarters below the mouth of Elk River.

At the foot of Big Muscle Shoals, and between that and the head of Little Muscle Shoals, lies the deep water of Bainbridge, or Campbell's Ferry pool or eddy, one mile and one-quarter in length, with a fall of 2 feet, and a depth varying from 8 to 57 feet.

The whole distance and fall, then, from Brown's Ferry to Florence, is as follows, viz:

	Distance.	Fall.
	Miles.	*Feet.*
From Brown's Ferry to head of Elk River Shoals, (deep)	2.6	1.7
Elk River Shoals	8.6	21.1
Lamb's Ferry pool, (deep)	6.3	5.4
Big Muscle Shoals	14.4	82.1
Campbell's, or Bainbridge, Ferry pool, (deep)	1.25	1.9
Little Muscle Shoals	5.35	22.0
Total	38.5	134.2

The object of the survey was to ascertain what means could be found for passing these obstructions and uniting the two dissevered branches of the Tennessee, which for two hundred and sixty miles below and two hundred miles above is navigable for the largest class of western river steamers, while smaller steamers are able to pass two hundred miles still further up the stream.

The work of the survey was begun accordingly by the construction at Chattanooga, Tennessee, of two flat-boats with the necessary skiffs, arranged, provisioned, and equipped for the accommodation of the necessary party during the entire season's operations; and on the 19th

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of June the expedition started on its journey of two hundred miles down the river.

Five days floating, night and day, with the current, assisted partly by oars, brought us to Brown's Ferry, twelve miles below Decatur, Alabama, where the party was organized for work, and operations begun on the 27th, on which date I started on my return to Chattanooga.

The party, as organized, was as follows:

First Lieutenant James F. Gregory, Corps of Engineers, whom I assigned to the command of the expedition, and to whom I furnished detailed instructions for the conduct of the survey.

First Lieutenant Benjamin D. Greene, Corps of Engineers; four civil assistants, Messrs. Long, Adams, Palmer, and Le Hardy, and twenty-six men, including one master, one cook, one waiter, and two pilots, who were to act also as boatmen.

In the division of duties, three parties were formed: one under Mr. Long, with an assistant and seven men, to run the transit and level line along the northern shore; one under Mr. Adams, with an assistant and seven men, to run the transit and level line along the southern shore: a third, under Lieutenants Gregory and Greene, with two boats and eight men, to attend to the establishment of stations, the triangulation and hydrography; while Mr. Le Hardy, with a pocket level, was assigned to the duty of sketching in the topography.

With this organization the work was begun on the 27th of June, and continued with such interruptions only as were occasioned by excessive heat and continued sickness, until the 15th of September, when the field-work was brought to a close at Florence. The party was frequently reduced by sickness of officers, assistants, and men, to one-half its working-force, and we were never able to keep it up to the standard of its organization. From the 5th of August to the 15th of September, about 25 per cent. of the whole number were unavailable for work on account of bilious fever, and chills and fever; and Assistant Adams was seriously sick, as were also several of the men.

Upon the closing of the field-work at Florence, the force was disbanded, the boats laid up, and Lieutenants Gregory and Greene, who were still suffering from malaria, were ordered to Painesville, Ohio, to complete the computations and plotting of their field-work, where also Mr. Le Hardy was afterward sent to join them as draughtsman.

During the progress of the survey, and as often as my other duties would permit, I made frequent visits to the party in order to familiarize myself as much as possible with the nature of the obstacles to be overcome and to watch the progress of the work. The topographical features of this region are so well described in the report of Mr. William B. Gaw, formerly assistant to Major Godfrey Weitzel, Corps of Engineers, as given in the report of the Chief of Engineers for 1868, that no repetition is here necessary. It is sufficient to state that the accuracy of this portion of his report is confirmed by the observations made during our own survey.

The results of the survey are best exhibited by the maps transmitted herewith, eight in number, each 36 inches wide and 52 inches long. Seven of them drawn to a scale of 600 feet to an inch, and the eighth, which is an index-map, being drawn to a scale of 4,000 feet to an inch. The topography of this work, which gives every 10-foot curve on both sides of the river, and the hydrography, cover a length of 27 feet, and an area 36.8 square feet.

The levels of the north and south sides were compared by means of trial-lines run across the river at Elk River Shoals, Green's Bluff Bar.

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and the railroad-bridge at Florence, where the difference was found to be but six-tenths of a foot—a most gratifying result, when it is considered that both lines were run over very difficult ground, filled with swamps, sloughs, dense cane-brakes and underbrush, and rugged and precipitous cliffs.

The work was carried on at a season particularly favorable for determining the character of the bottom, severe as it was in respect to health, comfort, and convenience; 6 and 8 inches depth was all that could be had in many places, and, at Poor-Horse Bar, but 3 inches was found, a fortunate rise in the river alone enabling the boats to pass over without resorting to the use of rollers.

The computations being finished, the draughting was begun in October by Mr. Le Hardy, and continued uninterruptedly, working seven hours a day, until its completion, on the 20th of March. The handsome and accurate maps which he has produced are his best commendation.

The amount of work accomplished by Lieutenants Gregory and Greene during this season's operations will challenge comparison with the best efforts of the Lake and Coast Surveys, and they are deserving of the heartiest commendation therefor.

Before entering upon a discussion of the cost of the various methods suggested of opening these shoals to navigation, I shall give a brief *résumé* of the history of previous efforts in the same direction.

As stated in the earlier pages of this report, the Tennessee is navigable from Florence, Alabama, to Paducah, Kentucky, at its mouth, two hundred and sixty miles distant, by the largest class of western river steamers, (the obstacles at Colbert Shoals being nearly removed,) while the same may be said of that portion of the river lying between Muscle Shoals and Chattanooga, two hundred miles in length. During the high-water season the river rises at Chattanooga 40 feet; at Brown's Ferry, 12 feet; on the Big Muscle Shoals, from 4 to 5 feet; and about twice as much on Little Muscle Shoals; at Florence, 20 feet; and at Waterloo, twenty-eight miles below Florence, 30 feet. This rise enables large vessels to pass up to Knoxville, two hundred miles above Chattanooga, and renders the Little Tennessee, the Holston, and the French Broad navigable for smaller steamers for some distance farther.

The Tennessee itself is a broad, deep, and beautiful stream, with more water than the Ohio, and with a permanent bed, its obstructions consisting almost exclusively of rock-reefs, with little or no sand or gravel, which prevents the formation of the shifting bars which obstruct the navigation of most of the western rivers.

Passing from Southwestern Virginia and Western North Carolina through the fertile valleys of Eastern Tennessee, Northern Alabama, and Western Tennessee and Kentucky, and by Northwestern Georgia and Northeastern Mississippi, it reaches a point near the center of the Mississippi Valley, within a few hundred miles of which are found the mouths of the Ohio, the Missouri, and the Arkansas, and offering thus (but for the single obstacle of the Muscle Shoals) a cheap and easy, and the only internal line of water-communication between the Southeastern States and the immense region watered by the tributaries of the Mississippi, it is not wonderful that its value as a highway for commercial purposes should early have attracted the attention of our statesmen, who saw in its opening a means of developing enormously the population, wealth, and resources of one of the richest agricultural and mineral regions which the United States possess.

Accordingly, in 1828, the board of internal improvement was directed, by act of Congress approved May 23, 1828, to make an examination of

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the Muscle Shoals, with a view to opening them to navigation, and to submit a plan and estimate therefor, which plan and estimate were submitted December 18, 1830, and were approved by the President in the March following.

The salient features of this project were the formation of three basins, by the construction of dams across the river, one below Brown's Ferry, one below Elk River Shoals, and one below Campbell's Ferry, and their connection with each other, and with the deep water at Florence, by a canal along the northern shore.

The construction of these basins was rendered necessary by the provision of the act of Congress that the scheme should provide for bringing the southern shore of the river into direct water-communication with the canal, which it was well understood would, if built, have to pass the shoals on their northern side.

To carry out the scheme of improvement presented by the board, which also related to the construction of certain works at Colbert's Shoals below Florence, Congress appropriated four hundred thousand acres of the public lands lying within the State of Alabama, which were to be sold and the proceeds applied to the construction of the works recommended by the board; and the execution of the work was confided to the State of Alabama, with the single condition that the work should be begun at the deep water near Florence, and carried up the river as far as the funds available would permit.

The funds accruing from this source, however, being manifestly inadequate to the completion of the work as designed by the board, the commissioners of the State of Alabama, who had the work in charge, deemed it best to apply them to the construction of that section of the proposed canal which was to connect the deep water at Lamb's Ferry with the deep water at Campbell's Ferry; and upon their application Congress removed the restriction which it had placed upon them in respect to beginning the work at Florence, and gave them the authority asked for to enable them to construct this middle section of the canal first; and the board of internal improvement was ordered to re-examine the question in relation to this proposed change in its scheme, and to report a modified plan and estimate accordingly.

Their report bears date March 25, 1831, and in it they state that it is "a plan not presented or approved by this board." And they further add, in relation to it, "that it will overcome about fourteen miles and six-eighths of the impediments of the river; but after passing these a boat cannot go farther for want of the improvements to pass over the impediments above and below." The work, however, was begun that year, 1831. In July, 1836, water was first let into the canal, which a few months later was thrown open to navigation—its lower terminus being in the eddy of Campbell's Ferry, (now Bainbridge Ferry,) and the upper terminus being about three miles below the Lamb's Ferry eddy, the funds not being sufficient to admit of the completion of the work to the eddy itself, where, however, it was eventually carried under a small additional appropriation.

The width of the canal as finished, varied from 60 to 70 feet at the water-surface, with a depth of 6 feet, and lock-chambers 32 feet wide by 120 feet between miter-sills, with an average lift of 5 feet.

The work, so far as done, was well done, and the canal was for a time extensively used; but the very objection to the scheme urged by the board of internal improvement in their modified report of March 25, 1831, found constant verification in the fact that boats which had passed through the canal were stopped commonly by the Elk River Shoals above

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or the Little Muscle Shoals below; so that often scores of vessels lay idly at one obstruction or the other, waiting for a rise in the river to enable them to pass.

In a letter dated May 14, 1838, Mr. Thomas Williams, the chief engineer of the canal, says:

A great quantity of cotton has passed through the Muscle Shoals Canal, but for some weeks past the unusual lowness of the water has completely suspended navigation; not that there is any difficulty in passing through the canal itself, but the water on the shoals above and below it (Elk River and the Little Muscle Shoals) is so shallow as to prevent boats from getting into it. There were a few days ago about seventy large flat-boats, loaded with cotton, (all of which had passed through the canal,) lying at Campbell's Ferry, waiting for a rise in the river to carry them over the Little Muscle Shoals. Many more are detained by the shoals above the canal. The steamer Holston, of more than one hundred tons burden, and intended for the Upper Tennessee trade, passed up the canal some time ago, but I am told is detained by shoals above the canal.

These difficulties, together with the failure of all attempts to obtain further appropriations either from Congress or from the legislature of the State of Alabama to maintain and extend the canal—a failure due, no doubt, in a great measure, to the financial distress of 1837 and the years immediately succeeding—gradually caused its abandonment. The lock-gates rotted and fell to pieces, leaks occurred, the dams across the creeks became broken and disintegrated, quantities of sediment washed into the bed of the canal, and now, over forty years since the work was begun, tow-paths, banks, and bed alike of this great work, which cost the country nearly $700,000, are overgrown with trees and heavy masses of shrubbery, while glimpses only of the fine masonry of its seventeen locks are to be caught here and there through the occasional openings of the dense growth which envelops them.

The results of my examination convince me that the scheme proposed by the board of internal improvement for the passage of this obstacle, and approved by the President in March, 1831, cannot be improved upon; and the work now remaining to be done, in order to carry it out, is to put the old canal around the Big Muscle Shoals in good condition, and to construct the canals around Elk River Shoals and Little Muscle Shoals, together with the basins proposed for connecting them with the south shore. The dams to be used in the formation of these basins should, of course, as originally proposed, be arranged with chutes for the passage of rafts.

The commerce of the western waters has changed so much in character since this work was begun, that the question of giving to the canal an increased capacity, suited to the size of the steamers and barges now employed, requires consideration. I shall, therefore, in my estimates, give the cost of completing the work as it was begun, *i. e.*, with the canal-trunk from 60 to 70 feet wide at the water-surface, 6 feet depth of water, and with the lock-chambers 32 feet wide by 120 feet long between miter-sills.

Also, the additional cost of lengthening the lock-chambers to 200 feet, the other dimensions of the canal remaining the same. Also, the cost of widening the canal to 100 feet at the water-surface, with the same depth, and lock-chambers 60 feet wide by 300 feet in length between miter-sills.

As a part of the old canal over four miles in length, built in the bed of the Tennessee at the foot of Rocky Bluffs, has a width of but 60 feet, this determines the limit of the width which can be given to the locks, unless a very heavy additional expense for widening this part is incurred, which I have thought it unnecessary to consider.

With this exception, the remainder of the canal is constructed through

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alluvial bottoms, and, by the use of the dams across the Tennessee before alluded to, the rock bottom upon which the masonry of nearly all the locks rests need not be excavated in the construction of the trunk of the canal.

The saving of expense resulting from this mode of construction will explain the great difference which exists between my estimates and those given in the report of Mr. William B. Gaw, before alluded to.

I have also given the estimated cost of the canal, upon the supposition that the new locks be constructed of the larger dimensions, while the old ones be left of their present size until the demands of commerce require their enlargement; but as the cost of this method of construction would be about the same as the cost of making all the locks 32 feet wide by 200 feet between miter-sills, while it would defer to a distant day the advantages which would be immediately conferred by the execution of the latter method of construction, it does not impress me favorably.

The number of new locks required to carry the canal around Elk River Shoals would be five, two guard or regulating locks, and three lift-locks; at Big Muscle Shoals, one guard-lock; at Little Muscle Shoals, two guard-locks and three lift-locks; total, eleven.

To reduce the number by increasing the lift would increase the expense by rendering necessary heavy embankments, or large amounts of rock excavation.

The estimates are, of course, greatly in excess of those made forty years ago, when the work would have cost but one-half or one-third of what it would now cost, and are as follows:

To complete the canal of the dimensions of the part already constructed between Lamb's and Campbell's Ferries, *i. e.*, 60 to 70 feet wide at water-surface, 6 feet deep, lock-chambers 32 by 120 feet between miter-sills—

Elk River Shoals.

9 miles of canal-trunk, at $40,000 per mile	$360,000	
3 locks, 8½ feet lift, at $50,000 each	150,000	
2 guard-locks, at $40,000 each	80,000	
2 crib-dams across the Tennessee, at $75,000 each	150,000	
		$740,000

Big Muscle Shoals.

1 guard-lock	40,000	
Repair of 17 locks, at $10,000 each	170,000	
Repair of fifteen miles of canal-trunk, at $25,000 per mile	375,000	
Dams and culverts	50,000	
		635,000

Little Muscle Shoals.

6½ miles of canal-trunk, at $40,000 per mile	260,000	
3 locks, 7½ feet lift, at $50,000 each	150,000	
2 guard-locks, at $40,000 each	80,000	
1 crib-dam across the Tennessee	75,000	
		565,000
		1,940,000
Contingencies, to provide against leakage, accidents, construction of coffer-dams, pumping, &c., 10 per cent		194,000
Aggregate cost		2,134,000
If, with the other dimensions of the canal remaining the same, the length of the lock-chambers between miter-sills be increased to 200 feet, the increased cost will be 28 locks, at $16,000 each		448,000
Total		2,582,000

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If, at the same time, the locks be all widened to 40 feet, making the lock-chambers 40 by 200 feet, the increased expense would be as follows: 28 locks, averaging $5,000 each	$140,000
Total	2,716,500

If the trunk of the canal be made 100 feet wide at the surface, 6 feet deep, and with lock-chambers 60 feet wide by 300 feet between miter-sills, the cost will be as follows:

Elk River Shoals.

9 miles of canal-trunk, at $55,000 per mile	$495,000	
3 locks, 8½ feet lift, at $110,000 each	330,000	
2 guard-locks, at $70,000 each	140,000	
2 crib-dams across the Tennessee, at $75,000 each	150,000	
		$1,115,000

Big Muscle Shoals.

1 guard-lock	70,000	
Rebuilding seventeen locks, at $50,000 each	850,000	
Widening fifteen miles of canal-trunk, at $33,000 per mile	495,000	
Dams and culverts	50,000	
		1,465,000

Little Muscle Shoals.

6½ miles of canal-trunk, at $55,000 per mile	357,500	
3 locks, 7½ feet lift, at $110,000 each	330,000	
2 guard-locks, at $70,000 each	140,000	
1 crib-dam across the Tennessee	75,000	
		902,000
Total		3,482,500
Contingencies, as before		193,500
Aggregate		3,676,000

The increased cost of making the new locks of the larger dimensions, while the remainder were left of their original size, would be—

6 lift-locks, at $60,000	$360,000
5 guard-locks, at $30,000	150,000
Total	510,000

which is but $63,000 more than the estimated cost of making all the lock-chambers 32 by 200 feet.

The foregoing estimates are based upon the supposition that the excavation and embankment would be equalized in practice, and that not more than one-quarter of the entire excavation would be in rock; and it is believed that they are liberal. It is quite probable that, in actual construction, a careful study of the ground would result in a considerable reduction below these estimates.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

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M 4.

EXAMINATION AND SURVEY OF THE COOSA RIVER, ALABAMA.

UNITED STATES ENGINEER OFFICE,
Paincsville, Ohio, March 23, 1872.

GENERAL: I have the honor to transmit herewith my report upon the examination and survey of the Coosa River, Alabama, so far as it has been extended at this date.

The instrumental survey begun in September, 1870, at Wetumpka, Alabama, by Mr. Henry C. Fillebrown, was closed in December of the same year at the bridge of the Selma, Rome and Dalton Railroad, sixty-eight and a half miles above Wetumpka, by reason of high water.

The unfortunate drowning of this gentleman at the Devil's Race, Coosa River, August 11, 1871, by the swamping of the boat in which, in company with him, I was making an official examination of the result of his previous season's work, left me, just at the beginning of the working season, without the necessary assistance for completing the survey, and I was compelled, therefore, to defer it until I could procure the services of an engineer upon whose judgment I knew I might rely.

Mr. J. C. Long, civil engineer, who had been engaged in the survey of Muscle Shoals, was eventually assigned to the charge of the Coosa survey, but as he was engaged at the time in conducting the survey for a canal route from the Tennessee to the Coosa, he was directed to finish that before beginning upon the Coosa. His survey will probably be completed in time to enable me to incorporate the result in my annual report for 1872, and in the meanwhile the report upon the preliminary examination of this part of the Coosa, from the bridge to Greensport, Alabama, made by Mr. Fillebrown, under the instructions of Colonel J. H. Simpson, Corps of Engineers, and to be found in the annual report of the Chief of Engineers for 1871, enables me to report upon the probable cost of opening to navigation that entire portion of the river lying between Wetumpka, Alabama, and Greensport, Alabama, about one hundred and thirty-four miles in length.

Before, however, giving the results of his labors, I must bear testimony to the sterling energy and excellent judgment marking every official act of Mr. Fillebrown which has come under my observation. Possessing a rare degree of discretion and integrity, he ended a long record of faithful service to the Government by giving up his life while in the performance of his duty; and his memory deserves this official recognition of his services.

As Mr. Fillebrown's survey was begun at Wetumpka, Alabama, near the mouth of the Coosa, and was carried up the river, I shall describe the obstacles to navigation as they occur in the same order; premising that the general system of improvement to be suggested will consist in the formation of slackwater navigation over the rapids by the construction of dams and locks, with one or two short stretches of canal where needed, and the removal from the channel-ways of dangerous and inconvenient rocks.

From Wetumpka to the bridge of the Selma, Rome and Dalton Railroad the river is sixty-eight and a half miles long, with a fall over the rapids, and requiring lockage, of 260 feet.

The river is broken up into pools or eddies of navigable water, separated by reefs, shoals, and rapids, sometimes of very great extent, absolutely impassable at low water, and dangerous in the best stages by reason of the crookedness of the channel-ways and the ragged rocks

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everywhere to be found along their borders and in mid-stream, reaching to the surface even where the water is forty or fifty feet deep.

The total length of navigable water to be found in this distance of sixty-eight and a half miles is about thirty-three miles, broken up into stretches varying in length from 600 yards to six miles, and varying in depth from 6 feet to 60 feet.

The intervening shoals vary from single reefs a few yards long in the direction of the current, and extending from bank to bank, to long series of shoals from a thousand yards to twelve miles in length. These obstructions consist almost entirely of rock, very little gravel being found.

The average width of the river is from 800 to 1,000 feet, though at "The Narrows" below Weduska Shoals, fifty-three miles above Wetumpka, it contracts suddenly to a width of 390 feet, while just below and above that point it is 1,800 feet and 2,500 feet wide respectively, and on Tuck-a-league Shoals, at a point a little below "The Butting Ram," it widens to 3,500 feet.

Up to Wetumpka the river is comparatively free from obstructions, and is navigable, whenever the Alabama is navigable, to Montgomery, between thirty and forty miles below.

OBSTRUCTIONS.

Wetumpka Rapids, extending from a little below the bridge connecting East and West Wetumpka to a point 1,400 yards above, with a fall of over 14 feet. This would have to be passed by a canal with two locks of about 7 feet lift each, and with a dam at the upper end.

Corn Creek Shoals, beginning one and a half miles above Wetumpka Shoals, near the mouth of Corn Creek. Length, 1,200 yards; fall, 6¾ feet. A dam and lock, with the removal of some rock from the channelway, would here be required.

Reefs one mile above Corn Creek to be blasted out.

Rose's, or Grey's Islands Shoals, beginning 1,400 yards above Corn Creek Shoals, a little over one mile in extent. Two dams and locks required, and the removal of some rock.

Reef two miles above and 1,300 yards below the mouth of the Salkahatchee requires blasting.

Then, after a mile of good water, comes the longest series of shoals without navigable water to be found on the river, extending from station 462 to station 1,094, a distance of twelve miles, with a fall of over 62 feet. The obstacles encountered in this distance are as follows:

Reefs, near foot of shoal, to be blasted. *Buyck's old landing*, shoals to be overcome by dam and lock with some blasting.

Reefs, Staircase Fall, between the mouths of Town Creek and Weloney Creek, three-quarters of a mile long, to be blasted.

Reefs, two miles above the mouth of Weloney Creek. Dam, lock, and blasting.

Then comes good water until we reach a reef one and a half miles above the mouth of Pinchoulee Creek, with a fall of 10 feet in a mile, where a dam, lock, and blasting must be resorted to.

A small gravel-bar near the mouth of Chestnut Creek needs removal.

Fish-Trap Shoals, two and a half miles above the mouth of Pinchoulee Creek, has a fall of 6 feet in 1,800 feet. Here a dam and lock would be needed, and a quantity of rock should be blasted out.

Duncan's Riffle, beginning five and a half miles above the mouth of Pinchoulee Creek, is regarded by boatmen as the worst and most dangerous place between Staircase Fall below, and Weduska Shoals above.

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Its length is 2,600 feet, in which it falls 8 feet. The danger results from the contraction of the low-water channel-way to a width of 120 feet, through which the water rushes with great violence in a very irregular course, with jagged rocks lying in all directions. To overcome this obstacle a dam and lock would have to be constructed at great expense, and a large quantity of rock would have to be removed.

From this point to the foot of House's Island, just above Zimmerman's Ferry, a distance of five and a half miles, the river is deep, without obstructions, and from 800 to 1,000 feet in width. A slight gravel-bar opposite the ferry would require some dredging.

At the head of House's Island a dam and lock would be required, which would back the water up to the foot of Tuck-a-league Shoals. Some blasting would also need to be done in the channel-way from the head to the foot of House's Island.

Tuck-a-league Shoals begin about two miles above Zimmerman's Ferry, and extend to near the foot of Johnson's Island, a distance of five and one-fourth miles, with a fall of 39 feet.

To overcome the obstructions met with in this distance, four dams, with locks, would be required, one at the foot of the shoals, one about a mile higher up, one at the foot of Sauley's Island, and one abreast of Pate's Island, while Sauley's and Pate's Islands should be connected by a dike, and a wing-dam should be thrown across from the head of Pate's Island to the eastern bank of the river; upward of 40,000 cubic yards of rock would also have to be removed from the channel-ways and in the excavation for the locks.

A mile above the head of Tuck-a-league Shoals, at the mouth of Yellow Leaf Creek, is a ledge of rocks through which a channel would have to be blasted.

Beginning at the mouth of Yellow Leaf Creek, eight and one-third miles above Zimmerman's Ferry, and extending to the head of Weduska Shoals, seven and one-third miles above, with a fall of 55¾ feet, the river is one mass of shoals, rapids, reefs—filled with rocks, islands, grass, and willows growing in the water, and varying in width from one thousand feet to eighteen hundred feet. In this distance, Paint Creek comes in from the east, and the Waxahatchee from the west. It was between these two points, and between the head of the cleared island, one and one-half miles below the mouth of Waxahatchee Creek and the west bank, that Mr. Fillebrown was drowned.

To render this portion of the river navigable, eight dams and locks would be needed. The first, just above the mouth of Yellow Leaf Creek; the second, a thousand yards below the mouth of Paint Creek; the third, 800 yards above that mouth; the fourth, about the middle of the large island above; the fifth, at its head; the sixth, at the Waxahatchee Shoals, near the mouth of the Waxahatchee; the seventh, about 1,600 yards above the mouth of the Waxahatchee; and the eighth at the foot of Weduska Shoals, just above "The Narrows," where the river suddenly contracts to a width of 390 feet.

From this point to Peckerwood Shoals, nearly seven miles above, the river is very deep, (from 40 to 60 feet,) free from obstructions, and from 600 to 1,000 feet broad.

At Peckerwood Shoal a dam and lock would have to be constructed, which would give good water up to Fort William Shoals, two and one-half miles above, where another dam and lock would have to be constructed.

Then comes a stretch of deep water, over five miles in length, which carries us to the foot of Bullock's Shoals, four miles below the railroad

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bridge, where the last dam and lock for this portion of the river would be required.

I append hereto estimates of the cost of improving this part of the river as suggested in this report, which, it will be perceived,

Amounts to the sum of		$1,923,020 00
Mr. Fillebrown's estimate for improving that portion of the river between the bridge and Greensport, Alabama, (see report of Chief of Engineers for 1871,) was	$278,484 50	
But the prices on which he based his estimate are certainly 50 per cent. too low, without taking into consideration the peculiar dangers to which this kind of work is subject; add 50 per cent	139,242 25	
		417,726 75
Total cost		2,340,746 75

for rendering the river navigable from Greensport, Alabama, to Wetumpka, Alabama, a distance of one hundred and thirty-four miles, with a fall of 360 feet, for vessels drawing 3 feet of water.

The dams, and portions of the locks, to be constructed of crib-work, filled with stone and heavily planked over; lock-chambers to be 200 feet between miter-sills, and 40 feet wide; head and tail bays to be of masonry.

The dams have generally been taken at 10 feet height, where no great injury would result to the farming lands along the banks of the river from giving them such a height. Where such injury would result, a lesser height is to be given. Their positions are given approximately; actual survey may demonstrate that these may be altered with advantage.

The amount of blasting indicated is, necessarily, but approximate, but it is believed to be sufficient.

DETAILED ESTIMATE.

Wetumpka Rapids:		
Masonry, 15,000 cubic yards, at $8	$120,000	
Rock excavation, 4,500 cubic yards, at $2	9,000	
Crib-dam, 400 feet, at $20	8,000	
Two locks, (stone,) $40,000	80,000	
		$217,000
Corn Creek Shoals and reefs above:		
Dam, 750 feet long, at $20	15,000	
Lock	25,000	
Rock excavation, 5,200 cubic yards, at $2	10,400	
		50,400
Rose's, or Gray's Island Shoals, and reef above:		
Dam, 950 feet long, at $20	19,000	
Dam, 540 feet long, at $20	10,800	
Two locks	50,000	
Rock excavation, 10,000 cubic yards, at $2	20 000	
		99,800
Twelve miles of shoals and reefs:		
Dam, 800 feet long, at $20	16,000	
Lock	25,000	
Dam, 850 feet long, at $20	17,000	
Lock, (Staircase Fall)	25,000	
Dam, 1,800 feet long	36,000	
Lock	25,000	
Canal, 600 feet long	10,000	
Rock excavation, 7,200 cubic yards, at $2	14,400	
Dam near Town Creek, 800 feet long, at $20	16,000	
Lock	25,000	
Dam near Weloney Creek, 900 feet long, at $20	18,000	
Lock	25,000	
Rock excavation, 8,000 cubic yards, at $2	16,000	
		268,400

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Reef near Pinchonlee Creek:

Dam, 1,000 feet long, at $20	$20,000	
Lock	25,000	
Rock excavation, 1,500 cubic yards, at $2	3,000	
Gravel excavation, 3,500 cubic yards, at $1	3,500	
		$51,500

Fish-Trap Shoal:

Dam, 1,150 feet long, at $20	23,000	
Lock	25,000	
Rock excavation, 2,800 cubic yards, at $2	5,600	
Gravel excavation, 3,000 cubic yards, at $1	3,000	
		56,600

Duncan's Riffle:

Dam, 920 feet long, at $20	16,400	
Lock	25,000	
Rock excavation, 6,900 cubic yards, at $2	13,800	
		55,200

Zimmerman's:

Gravel-bar, 700 cubic yards, at $1		700

House's Island:

Dam, 1,050 feet long, at $20	21,000	
Lock	25,000	
Rock excavation, 2,200 cubic yards, at $2	4,400	
		50,400

Tuck-a-league Shoals:

Dam, 730 feet long, at $20	14,600	
Lock	25,000	
Dam, 1,150 feet long, at $20	23,000	
Lock	25,000	
Dam, 800 feet long, at $20	16,000	
Lock, (Sauley's Island)	25,000	
Dam, 820 feet long, at $20	16,400	
Lock, (Pate's Island)	25,000	
Dike, 320 feet long, at $20	6,400	
Wing-dam, 520 feet long, at $20	10,400	
Rock excavation, 40,000 cubic yards, at $2	80,000	
		297,800

Yellow Leaf Creek:

Rock excavation, 3,200 cubic yards, at $2		6,400

Shoals to head of Weduska:

Eight dams, 10,300 feet in length, at $20	206,000	
Eight locks, at $25,000	200,000	
Rock excavation, 20,000 cubic yards, at $2	40,000	
		446,000

Peckerwood Shoals:

Dam, 1,500 feet long, at $20	$30,000	
Lock	25,000	
Rock excavation, 1,000 cubic yards, at $2	2,000	
		57,000

Fort William Shoals:

Dam, 1,600 feet long, at $20	32,000	
Lock	25,000	
		57,000

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Bullock's Shoals:		
Dam, 1,800 feet long, at $20	$36,000	
Lock	25,000	
Rock excavation, 2,000 cubic yards, at $2	4,000	
		$65,000
Total		1,748,200
Contingencies, 10 per cent		174,820
Total, including contingencies		1,923,020

for that portion of the river lying between Wetumpka, Alabama, and the bridge of the Selma, Rome and Dalton Railroad.

The prices above given are considerably below the contract prices for work on the Tennessee River, but could be very much more reduced by the employment of hired labor instead of the contract system. Abundance of good material, wood and stone, can be had in the vicinity of every point where improvements have been proposed.

The region passed through by this portion of the river is very rich in coal and iron, the production of which could not fail to be greatly encouraged by the prosecution of the improvements herein suggested.

Two maps of this portion of the river are transmitted herewith.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

M 5.

EXAMINATION OF THE OOSTENAULA RIVER.

CHATTANOOGA, TENNESSEE, *May* 15, 1872.

SIR: I have the honor to present the following report on the reconnaissance of the Oostenaula River, made in accordance with your written instructions, dated March 11, 1872.

The Oostenaula, heading in the Blue Ridge more than one hundred miles above Rome, flows in a southeasterly direction, crossing the Western and Atlantic Railroad at the small town of Resaca. From this point the reconnaissance was made in a skiff procured for the purpose, and the following are the field-notes recorded during the examination:

REPORT ON THE RECONNAISSANCE OF THE OOSTENAULA RIVER.

Beginning at Resaca, the grade of railroad bridge is 34½ feet above water: river two feet higher than low summer water; width of river, from 80 to 90 yards; water, from 7 to 10, and more feet deep.

Four miles below Resaca, a shoal, extending across the river 100 yards long, and 200 yards additional of shoal water only from 4 to 5 feet deep. One to one and a half miles farther, the same condition of the channel as above, from 200 to 300 yards; the bottom, however, is gravel, and the channel could easily be deepened. Rocky bluffs frequently close in on the river, first on one side, then on the opposite. Two to three miles farther on, a light bar 50 to 60 yards long, with 4 to 5 feet water, and river 70 to 80 yards wide. Two miles farther, a small shoal

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extending across the half width of the river, and not more than 100 feet long. Above and below this shoal, for from 400 to 500 yards, only 5 feet depth of water, with gravel and sand bottom. The rocky bluffs disappear or set back from the river, which now is 70 to 80 yards wide. Two miles farther, at the Calhoun Bridge, a heavy but short shoal, extending across the river, with deep water above and below. One to one and a half miles farther, Tanner's Ferry, and one quarter mile below that, a short shoal. Thence good water to Dobbins's Ferry. Water near Dobbins's Ferry, 4½ to 8 feet deep, and can be forded in summer, but the bottom is gravelly. A short distance farther, good water, with average width of river from 60 to 80 yards, we reach Griffin's Ferry, being still in deep water. Half a mile below Griffin's Ferry a light, short shoal, and 100 yards below this shoal, water deep enough on the left bank, and, on the right, a like shoal, only 6 to 6½ feet water, with gravel bottom, and width of river 60 to 70 yards. About three-quarters of a mile farther, a light shoal, with 5 feet water, and width of river 40 to 50 yards. Four to five miles farther, Miller's Ferry, and, 150 to 200 yards below it, a heavy shoal from 100 to 150 yards long. Three miles farther, a light shoal 50 to 60 yards long, with gravel bottom, and width of river 70 yards. We next reach Bell's Ferry. Bottom of river consists mostly of gravel and sand, and width from 70 to 80 yards. Valley at some places very narrow, the rocks coming in close to the water's edge. Fifty yards below Bell's Ferry, a small shoal extending half way across the river, and 40 to 50 yards long. From ten to twelve miles farther, a light shoal 60 to 80 yards long, with only 3 to 4 feet water, and width of river 60 to 70 yards. From one to one and a half miles farther, another light shoal, the same in character to the one first above.

From Resaca to Rome the distance is from forty-eight to fifty miles. The grade-line of railroad at Rome is 542.2 feet above tide, and the surface of water about 30 feet lower, or 512.0 feet above tide-water. Boats of 18 inches draught have navigated the Oostenaula as far as Resaca in low summer water. Such are the notes made on the reconnaissance of the Oostenaula. I will next present the statement kindly furnished by Captain F. M. Coulter, who navigated for some time the Oostenaula from Rome to Resaca.

Captain Coulter's memoranda of the obstructions in the Oostenaula.

1st. Below Resaca is shallow water, about 3 feet deep for three-quarters of a mile.

2d. Rocky shoals about three-eighths of a mile long; lowest water about 28 inches; rocks easy to break up.

3d. Ledge extending square across the river, dipping to the east. Water on east side 20 inches, with gravel bottom, and bluff on the west side.

4th. Detached rocks, with bluff on the east, and gravel and alluvial sediment on the west side, and 3 feet depth of water.

5th. Bluff on the east side, with short bend, and rock reef extending two-thirds across the river, and 4 feet depth of water. Leaning timber to be cut on point opposite reef, and just below shallow; only 3½ feet water for quarter of a mile.

6th. Loose rock in upper end of shoal, with 3 feet water and gravel in lower part, with only 20 inches water, but believes that the gravel is underlaid with rock.

7th. At Calhoun Rock Reef, with bluff on east side, and water 3 feet deep on west side.

8th. Gravel for 75 yards, with 3½ feet of water.

9th. Rock ledge on east side, 75 yards long, with 2 feet water, and bluff on west side.

10th. Loose small rocks, with probably solid rock bottom, and bluff on the west.

11th. Rocks on the west side, half way across, with ledges, and detached alluvium on the east. Length, one-quarter mile, and depth 15 inches.

12th. For 75 yards, 3½ feet water, with gravel bottom.

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13th. For 200 yards, 4 feet water, with gravel bottom.
14th. For 75 yards, 30 inches water, with gravel bottom.
15th. For one-quarter mile, 4 feet water, with gravel bottom.
16th. For 150 yards gravel, underlaid with rock, and 15 inches depth of water, and for one half mile further, 4 feet water.
17th. Slaty ledges half way across. Length, 250 yards, and 2 feet water. Some small, loose rock, and bluff on the east.
18th. Shandly Shoal, 150 yards long, 30 inches water, and loose gravel bottom.
19th. Shelly Rocks, 250 yards long, and 30 inches water; then, for one half mile, 3 feet water.
20th. Detached rocks on the west side, and limbs, logs, and sediment on the east, with 3 feet depth of water.
21st. Slaty rocks and gravel, 150 yards long, with 30 inches water.
22d. Gravel, 150 yards long, and 30 inches of water.
23d. Gravel, 100 yards long, and 3 feet of water.
24th. Flat rocks on west side, and gravel on east, 200 yards long, and 30 inches water.
25th. Ships Island, narrow zigzag chute, 400 yards long, 2 feet water, and coarse gravel bottom.
26th. Gravel, 250 yards long, and 30 inches water.
27th. Gravel, 250 yards long, and 30 inches water.
28th. Gravel, 400 yards long, and 30 inches water.
29th. Rock ledge, 40 feet thick, and 15 inches water.
30th. For one-half mile, 30 inches of water.
31st. Gravel, 100 yards long, and 30 inches of water.
32d. Slaty rocks, 250 yards long, and 3 feet water.
33d. Gravel, 100 yards, with 20 inches water.
34th. Gravel, 200 yards, with 2 feet water.
35th. Rocks on west side, and gravel and sediment on the east, 350 yards long, with 3 feet of water.
36th. Rocks on the east, and gravel on the west, one mile above Rome.

This closes the description of the Oostenaula, as given by Captain Coulter, and I rely more upon his statements than upon my reconnaissance, for the reason that his was the result of experience obtained when the water was low, while my notes were made when the water was at least 2 feet higher than extreme low water. Captain Coulter adds:

The depths of water given are the least depths at the given places, the average depth being much more; sometimes a few feet, and again a few yards, being the highest points of the bars and rocks.

It will be observed that one-third of the shallow places have 3 feet of water in dry summer weather, while the remaining 24 points can be made the same depth at very small cost.

From ten to twelve thousand dollars will probably be sufficient. The distance from Resaca to Rome by river is forty-eight miles, and the fall 111 feet; the elevation of river above tide at Resaca being 623 feet, and at Rome, 512 feet.

Very respectfully, your obedient servant,

R. C. McCALLA,
Civil Engineer.

Major WALTER McFARLAND,
United States Engineer Corps.

M 6.

LINE OF WATER-COMMUNICATION BETWEEN THE MISSISSIPPI RIVER AND THE ATLANTIC.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tennessee, May 25, 1872.

GENERAL: I have the honor to transmit herewith my report upon the proposed line of water-communication between the Mississippi River

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and the Atlantic Ocean, by way of the Ohio, Tennessee, Coosa, Etowah, Ocmulgee, and Altamaha Rivers, and canals from the Tennessee to the Coosa, and from the Etowah to the Ocmulgee; which includes reports upon the following examinations and surveys ordered by act of Congress of March 3, 1871, viz:

1st. For a survey beginning at or near Guntersville, on the Tennessee River, to the head-waters of the Warrior and Coosa Rivers, Alabama, with the view of determining the practicability of uniting the waters of the Tennesseee River with the waters of the Warrior or Coosa River, for the purposes of navigation, and estimates for necessary locks and dams to extend the navigation on said river to the last-named place.

2d. For examination and survey of the Etowah River, from its mouth up to Cartersville, Georgia.

3d. The resurvey of the Tennessee River from Brown's Ferry to Florence, Alabama.

And also by Senate resolution of March 30, 1871, which is as follows:

4th. *Resolved*, That the Secretary of War be, and he is hereby, requested to cause the Engineer Department of the United States to extend the survey of the Etowah River (already ordered) so as to embrace estimates for a canal connecting said river with the Ocmulgee River, with a view to opening a direct and unobstructed water communication between the waters of the Mississippi and the Atlantic Ocean, and to report to the Senate.

Which orders and resolutions, as well as their object, were communicated to me by your letters of March 22 and April 3, 1871, accompanied by a map containing a sketch of the proposed route.

The work of the survey was begun in June by the organizing of a party under Lieutenants James F. Gregory and Benjamin D. Greene, of the Corps of Engineers, for the "resurvey of the Tennessee River, between Brown's Ferry and Florence, Alabama," which includes the obstacle known as the Muscle Shoals.

This survey was begun in June and finished in September, and it had been my intention, upon its completion, to send the same party to make the canal surveys from the Tennessee to the Coosa, and from the Etowah to the Ocmulgee. But the season had been a trying one, and officers and men alike were prostrated by the heat and the malaria, and I found it necessary, therefore, to organize two other parties, one of which, under Mr. J. C. Long, civil engineer, who had done good service in the Muscle Shoals survey, was to seek for a practicable route from the Tennessee to the Coosa, across the Sand Mountain; and the other under Mr. R. C. McCalla, civil engineer, the former able chief engineer of the Alabama and Chattanooga Railroad, was to survey the route from the Etowah to the Ocmulgee.

Both parties took the field in October, and, after a season of unusually severe winter weather, brought their outdoor labors to a close in the February following. The detailed reports of the chiefs of these parties are appended hereto. The maps of their surveys will be forwarded when completed. The detailed report upon the Muscle Shoals survey and its accompanying maps were transmitted to you on the twenty-third of March. The route, as proposed, beginning at the mouth of the Ohio River, is as follows, viz: Up the Ohio to the Tennessee; up the Tennessee, passing Muscle Shoals, to the mouth of Short Creek, two miles and a half below Guntersville, Alabama, from the mouth of Short Creek, by canal and slackwater navigation, across Sand Mountain and down the valley of Well's Creek, to its junction with the Coosa, two miles and a half below Gadsden; up the Coosa to Rome, Georgia; from Rome, by canal and slack-water navigation, up the valley of the Etowah and Little Rivers, across the Chattahoochee plateau, down the Yellow and Ocmulgee Rivers to Macon; thence continuing down the Ocmulgee to the Altamaha, and down the Altamaha to the sea, a total distance of thir-

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teen hundred and thirty-three miles, one thousand and thirty-three of which is by river and the remaining three hundred by canal and slack-water navigation.

The canal around Muscle Shoals, apart from the duty which it is intended to perform as a link in the proposed chain of water-communication between the Mississippi River and the Atlantic Ocean, is designed to overcome the great obstacle which these shoals interpose to the free navigation of the Tennessee, and should therefore be adapted to the passage of the largest steamers ever likely to be employed upon it, in order that the valley of the Upper Tennessee, so rich in agricultural and mineral resources, may no longer, for want of cheap and easy water-communication with the great centers of wealth and population in the Mississippi valley, be hindered in its development and deprived of the advantages enjoyed by the regions watered by all the other great tributaries of the Mississippi.

The proposed canal between the Tennessee and the Coosa Rivers will also, besides serving as a link in the same great chain, have another duty to perform; for, in connection with the improvement of the Coosa, it will open direct communication between the valley of the Tennessee and the rich cotton and mineral regions of Central and Northern Alabama, and will furnish a short and easy water-route from Eastern Tennessee and Northern Georgia and Alabama to Mobile and the Gulf of Mexico.

For this reason this also should be adapted to the passage of steamers, but, unfortunately, the narrowness and crookedness of the rocky valleys through which this canal must pass render this impracticable, except at a cost out of all proportion to the advantages to be gained by its accomplishment, and we are compelled, therefore, to restrict the dimensions of the canal to such as seem best adapted to the service of the trade which is likely to seek it, and to the character of the boats which the nature of the river-portions of the route may compel a resort to.

The traffic over this route would, of necessity, be chiefly in bulky and weighty articles—grain, ores, coal, lumber, and salt provisions—and the boats for conveying these should be as large as possible. It is designed to improve the river-portions of the route so that during the dry season, or season of lowest water, say from July to October, 3 feet water may always be found at the bars and shoals. During the remainder of the year there will be no difficulty in carrying 5 or 6 feet over the same portions, and this enables us to fix the dimensions of the canal. By making it 70 feet wide at the water-surface, and 5 feet deep, with lock-chambers 30 feet wide and 120 feet long between miter-sills, we permit the passage of boats 112 feet long by 28 feet beam. Supposing they draw 15 inches when empty, they will have a capacity, when loaded down to 4 feet 6 inches, of 300 tons=10,000 bushels of grain; and during the season of low water, when they can be loaded down to only 3 feet, their carrying capacity will be about 170 tons=about 5,600 bushels of grain.

The smaller grain-barges made use of on the Upper Mississippi have an average capacity of about 450 tons each, and are 26 feet beam by 150 feet in length, with a draught of about 5½ feet when loaded to their full capacity. These barges are commonly lashed alongside their tow-boats; and as many of the low-water channels of the Upper Mississippi are but 60 feet wide, no greater beam can be given to the barges, and their great capacity is gained by giving them great length. It would be very desirable to give to the canals now under discussion such dimensions as

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would admit of the passage of these Upper Mississippi barges, but the excessive crookedness of their course, before referred to, involving numerous comparatively sharp turns, makes it necessary to reduce the length of the boats as much as possible; and to give them the necessary capacity their beam has been increased accordingly. Steamboatmen assure me that this change of shape will offer no hinderance to their easy management in tows, which is the method by which, in groups of six or seven, they would commonly pass over the river portions of the route.

The difficulty which boats would experience in passing each other by the ordinary method in the curved portions of this canal makes it necessary to construct two *tow-paths*—one to be restricted to the use of boats moving toward the sea, and the other to the use of boats passing in the contrary direction.

The Etowah River, from Rome to Cartersville, besides being fitted for the passage of such vessels as might pass through the proposed canal, between the Tennessee and the Coosa, should be adapted also to the passage of such steamers as ply now upon the Coosa, below Rome. It has not been definitely ascertained whether this can be best accomplished by the construction of a canal, or by a resort to slackwater navigation. The difference of cost of the two methods, however—because of the extent of the obstructions in the stream—cannot be very great; and the estimate, therefore, is for a canal over this portion of the route similar to that proposed for connecting the Tennessee and the Coosa, with lengthened locks if necessary. A dam and outlet-lock at Cartersville would enable steamers to load and unload at that place, making use of the canal in their trips between Cartersville and Rome.

The canal between Cartersville and Macon, on the Ocmulgee, should be of the same character as the two portions last mentioned, *i. e.*, suited to barge navigation; for barges probably for many years to come will suffice for all the traffic likely to take place by this route between Northern and Central Alabama and Georgia.

I shall now proceed to describe in detail the various divisions of the route, in the order previously mentioned, giving, as nearly as it could be obtained from what is essentially merely a preliminary examination and survey, the probable cost of fitting them for the passage of such boats as have been described.

Ohio division.—From Cairo, on the Mississippi, at the mouth of the Ohio, up the Ohio to Paducah, Kentucky, at the mouth of the Tennessee; distance, fifty miles, steamboat measurement.

By Major Merrill's report of October 1, 1870, to be found in the report of the Chief of Engineers for 1870, the worst places in this division, needing immediate improvement, are the Little Chain, Grand Chain, and Cache Island, distant fourteen, twenty-three, and thirty-eight miles respectively from Paducah. The cost of their improvement is given approximately at $45,000.

Tennessee division.—From Paducah, Kentucky, at the mouth of the Tennessee, up that river to Florence, Alabama, at the foot of Muscle Shoals; distance, two hundred and fifty-five miles, Coast Survey measurement.

The greater portion of this division furnishes depth enough for the passage of any boat that floats on the western waters, but scattered along the line are numerous reefs and bars on which, during the season of lowest water, less than 3 feet water is to be had, while the channelways of many others, though sufficiently deep at low water, are so crooked and narrow that it would be impossible for tows to pass them,

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and, therefore, need to be improved before they can be used for the purpose now under discussion.

The most serious of these obstructions is the group of reefs and bars known as Colbert Shoals, about seventeen miles below Florence, Alabama, which, next to the Muscle Shoals, constitute the most serious obstacle to be met with on the whole line of the river.

In the same vicinity are the obstructions at Seven Mile Island and Buck Island, a few miles above Colbert Shoals, and those at Bee Tree Island, a few miles below Colbert Shoals.

The water at these obstructions, during the lowest stage of the river, is from 12 to 20 inches in depth, and all communication by boat, between Florence and the lower river, is cut off, steamers being unable to ascend beyond Eastport and Waterloo, about thirty miles below Florence. Attempts have been made, within the past four years, under congressional appropriations, to improve the river at these points so that 3 feet water might be carried over them at the lowest stage; but the incompetence of the contractor who had undertaken the work has, so far, prevented the accomplishment of this design. It is hoped, however, that the balance yet unexpended will enable us to get the desired depth before the beginning of the low-water season of 1872. To secure 5 feet depth of water over this obstacle during the remainder of the year may require the construction of a short section of canal with a lock, the cost of which cannot be determined without a minute survey, but which may be set down at not less than $300,000.

Descending the river, we find that improvements of some kind or other—removing rock or gravel, or constructing wing-dams, in order to straighten or widen the channels, or to give them sufficient depth—will be required at the following points, viz: Bear Creek Shoals, Indian Creek, Big Bend Shoals, Diamond Island, Wolf Island, Chalk Bluff, Beech Creek Shoals, Buffalo Shoals, Armstrong's Tow-head Bridge, at Johnsonville, Duck River Shoals and Suck, Turkey Island Shoals, White Oak Island, Harrican Island, Leatherwood Shoals, Sandy Island, Panther Creek Island, McCullough's Bar, Blood River Island, Pentecost Tow-head, Widow Reynolds's Bar, Grubb's Tow-head, Little Chain, and Grand Chain.

At most of these points but a small amount of work would be required to make the low-water channel sufficiently broad and deep. As an accurate estimate cannot be given without an accurate survey, I have roughly fixed the probable average cost of improving these points at $5,000 each, except Big Bend Shoals, which, being over three miles in length, will cost a large amount. This and Duck River Shoals are the two most troublesome points below Colbert Shoals. During the greater portion of the year 3 feet water may be carried over either, but during the low-water season they have been known to have as little as 22 inches over them, though it seldom falls below 30 inches. The entire cost of securing 3 feet depth over the whole distance during the low-water season, and 5 feet depth during the ordinary stage of water, may be set down as not less than $500,000.

Most of these obstructions are not such as to materially interfere with the passage of the small steamers now employed on the Tennessee, but they would become serious obstacles to tows, which, in the event of the opening of this route, would constantly pass up and down the river; for, to admit of the passage and easy management of a steamer, with a barge on each side of her, the channel-ways would all have to be straightened and widened to not less than 150 feet.

Muscle Shoals division.—Extending from Florence, Alabama, up the

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Tennessee, passing Little Muscle Shoals, Big Muscle Shoals, and Elk River Shoals, to Brown's Ferry, Alabama, a distance of thirty-eight miles by survey, which would have to be passed entirely by canal; and, for reasons stated in an earlier part of this report, this canal should be constructed for the passage not only of such boats as may be designed to pass over the remaining portions of the route, but also for the largest steamers ever likely to be employed in the Tennessee River trade.

The survey of this division was begun in June, under Lieutenants James F. Gregory and Benjamin D. Greene, of the United States Corps of Engineers, and was finished in September, and my report thereon and the accompanying maps were transmitted to the Chief of Engineers on the 23d of March last.

The dimensions proposed for this canal were as follows, viz: 100 feet wide at water-surface and 6 feet deep; lock-chambers, 60 feet wide by 300 feet between miter-sills; and its estimated cost was $3,676,000. For fuller details see my report, a copy of which is appended hereto.

Alabama division.—Extending from Brown's Ferry, at the head of Muscle Shoals, up the Tennessee to the mouth of Short Creek, two miles and a half above Guntersville, Alabama, distance seventy-five miles by steamboat measurement.

This portion of the river is broad, straight, and almost free from obstructions, with abundant water except at Gunter's Bar, Gunter's Reef, Flint River, Tow-head, Whitesburgh-Shoals and Reefs, and Limestone Shoals, where, during the lowest stage of the river, the depth of water varies from 10 to 20 inches.

Here, too, in the absence of an accurate survey, we are compelled to depend upon an approximate estimate, which I put at $75,000, to insure 3 feet depth at the lowest stage of the river, and 5 feet at the ordinary stage, with channel-ways not less than 150 feet in width.

Sand Mountain division.—Extending from the mouth of Short Creek, two and a half miles above Guntersville, on the Tennessee, by canal and slackwater navigation across Sand Mountain, and down the valley of Wills Creek to its junction with the Coosa, two miles and a half below Gadsden, Alabama; distance, fifty and one-half miles, of which thirty-three is by canal and seventeen and a half by slack-water.

The survey of this division was made under the act of Congress ordering "a survey, beginning at or near Guntersville, on the Tennessee River, to the head-waters of the Warrior and Coosa Rivers in Alabama, with the view of determining the practicability of uniting the waters of the Tennessee River with the waters of the Warrior or Coosa River, for the purposes of navigation," &c.

This was altogether the most difficult point to determine in the whole survey, and the success of the whole scheme depended upon whether a practicable canal-route could be found by which the two rivers might be connected. The Tennessee and the Coosa, in the vicinity of Guntersville, approach within thirty-five miles of each other before turning, the one in a northwesterly and northerly direction to join the Ohio, and the other in a westerly and southerly direction, to join the Alabama on its way to the Gulf of Mexico. And they are here separated by Sand Mountain, a spur of the Cumberland range, which, after leaving the Tennessee at Chattanooga, runs for a hundred and fifty miles or more in a southwesterly direction, with a gradually falling crest, which, on the division now being described, is but 400 feet above low water of the Tennessee at Guntersville, and 464 feet above low water of the Coosa at Gadsden.

It was generally believed that the rugged character of this obstacle.

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and the difficulty, if not impossibility, of obtaining a water supply, except at an enormous and unwarrantable cost for tunneling, would effectually prevent the connection of these two rivers by canal, at least at this point. The results of Mr. Long's survey, however, show that there are two practicable routes across it, the one passing up the valley of Short Creek, the other up the valley of Town Creek; on either of which an abundant supply of water for the service of the canal can be obtained during eight months of the year, while during the remaining four months, by resorting to the use of storage reservoirs, a sufficient supply may be obtained.

In my preliminary report dated March 28, I stated that the question of water supply made it probable that the Town Creek route would be the preferable one. Information since obtained, however, show that a feeder, fifteen miles in length, can be run from Town Creek to the Short Creek route, and as this is the shorter by thirty miles, and the cheaper by $1,000,000, I have adopted it as the proper route.

Town Creek, which runs upon the top of Sand Mountain, is some sixty or seventy miles in length, and at the time Mr. Long examined it, furnished, according to his report, a supply of 36,000 cubic feet of water per minute. This result, however, was attained by assuming the surface-velocity as the average, and should be reduced, therefore, by two-tenths, which fixes the supply at 28,800 cubic feet per minute, and as we cannot count upon saving more than one-half of this amount in its passage through fifteen miles of feeder, 14,400 cubic feet per minute is the supply which, in the best season, we have to depend upon for the service of the canal, which amounts to 20,736,000 cubic feet per day.

The allowance for evaporation and filtration given in Mr. Long's report, *i. e.*, one-sixth of a foot in depth per day, is taken from Professor Rankin's estimate for English canals, and is far exceeded in many of our American canals, as in some of the New York and Pennsylvania canals, where, including leakage, it rises as high as 6 and 8 inches per day. As we cannot be certain of attaining any better results than have there been attained, I think it best to estimate the loss from these causes at 6 inches in depth per day, which would amount to 6,098,400 cubic feet per day. This leaves a balance of 14,637,600 cubic feet of water per day available for lockage; which, upon the hypothesis that one-half the boats are laden and the other half empty, and that two prisms of lift are required for the passage of each boat, would be sufficient for the service of two hundred and fourteen boats, passing through a lock of 12 feet lift; and this, on the supposition that it takes seven minutes for the passage of a single boat, is but eight boats in excess of the full capacity of the canal.

It is plain, then, that as there is so little excess of water, some other means must be adopted for the service of the canal during the dry season, and the expedient recommended is the construction of several storage reservoirs.

Their capacity, however, should be made two or three times greater than those alluded to in Mr. Long's report, and estimated for, which can be accomplished by increasing the dimensions of the dams proposed.

The prices given in this estimate are very fair, but I think that in the estimates of the amount of work to be done on this division, a sufficiently large margin is not allowed for the rectification and adjustment of the exceedingly crooked course pursued by the line, to the necessities of canal-navigation. Many of the turns to be encountered are so sharp that heavy cuttings, and perhaps tunneling, will have to be made through the intervening rocky points.

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Mr. Long estimates the cost of constructing this route, including canal, slackwater navigation, and feeder, at	$9,518,415
Cost of storage reservoirs	552,192
Total	10,070,607
To this, I think it necessary to add, for increasing the size of the storage reservoirs and rectifying the course of the canal	1,500,000
	11,570,607

which is the total estimated cost of this division. No work whatever should be begun on this division until a careful gauging of Town Creek, continued throughout the dry season, shows what water supply it is then able to give.

The report of Mr. Long, who has my commendation for the zeal and vigor displayed by him in the conduct of this survey, is appended hereto.

Coosa division.—Extending from the mouth of Wills Creek, two and a half miles below Gadsden, on the Coosa, up that river to Rome, Georgia, at the junction of the Etowah and Oostenaula; distance, one hundred and fifty-three and a half miles, by steamboat measurement.

This portion of the route is now navigable at all seasons of the year for vessels drawing 2½ feet water. In the absence of a detailed survey of the obstacles which prevent the passage of vessels drawing 3 feet water over this route during the season of lowest water, I have made a *pro rata* comparative estimate for the improvement, taking as a basis the cost of improving the Tennessee between Florence and Paducah—the two rivers being entirely similar in character—and I put the cost of improving this division at $100,000.

Georgia division.—From Rome, Georgia, at the mouth of the Etowah, up that river to a point a short distance above Cartersville; thence across the country to Macon, on the Ocmulgee River; distance, two hundred and eleven and a quarter miles, by actual survey and estimate.

The survey of this route covers the requirements of the Senate resolution of March 30, 1871, given on page 2 of this report.

Mr. R. C. McCalla, civil engineer, the engineer to whom I intrusted the survey of this division, has made so full a report that little further need be said upon the subject. The route follows as much as possible the valleys of the creeks flowing into the Etowah and Ocmulgee Rivers, and crosses the Chattahoochee by an aqueduct 117 feet above the level of the river. The broken and rugged character of the country makes a portion of the route quite crooked, and caused some delay in finding a satisfactory route across it, but there are no real engineering difficulties in the way of its construction. The summit-level, thirty-three miles in length, passes through a tunnel 3,200 feet in length, and then over the aqueduct before mentioned, and is supplied from the Chattahoochee itself by a feeder forty miles in length.

Mr. McCalla's estimate of the cost of constructing this division is $20,435,684, which is, I think, very fair. His report, to which I invite attention, is appended hereto.

The Altamaha division.—From Macon, on the Ocmulgee, down that river and the Altamaha, into which it empties, to Darien, Georgia, a distance of five hundred miles, steamboat measurement; with a branch either to Savannah or to Brunswick, Georgia. No survey or examination of this portion of the route has been made, and all the informa-

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tion I have concerning it has been furnished me by steamboat-men, engineers, and other citizens resident in the vicinity of the river. Mr. Butts, compiler of a map of the State of Georgia, and Captain William Taylor, of Hawkinsville, Georgia, who boated on these rivers from 1830 to 1866, agree as to the distance by river from Macon to Darien given above.

Captain Taylor states that during the low-water season, which lasts three or four months, from 2½ to 3 feet water can be carried over this entire distance; and during the remainder of the year 6 or 7 feet. He states also that there is no point on the river below which a depth of 5, 4, or 3 feet can be had all the year round; that there are many bars and shoals, very few of which are shifting; that they are formed by sand, rock, and fallen trees; that there are no rapids on the river except at a very low stage of the water, and that the river rises during freshets from 8 feet at Darien, to 25 feet at Macon; and he thinks much trouble would be saved by carrying the canal to some distance below Macon.

President Hazlehurst, of the Macon and Brunswick Railroad, who is an engineer by profession, and who is perfectly familiar with the whole region through which his road runs, tells me that he does not think that more than 20 inches can be depended upon between Macon and Hawkinsville during the dry season, nor more than 3 feet during the remainder of the year.

The testimony shows clearly enough that both rivers are very greatly obstructed, and if Mr. Hazlehurst's opinion is correct, it is probable that the only way to insure a draught of 3 feet at low water, and 5 feet at the ordinary stage of water, between Macon and Hawkinsville, would be to extend the canal to the latter point, a distance of about forty-five miles by rail, which at $50,000 per mile would cost $2,250,000. The cost of improving the remaining four hundred miles of river can only be surmised; but if, as Captain Taylor says, there is no point on the river below which 3 feet depth can be had all the year round, the probable cost of improving it will not fall short of $250,000, and the total cost of adapting this section to the purposes of the canal would be $2,500,000.

As the mouth of the Altamaha furnishes but a poor harbor for sea-going vessels, it would be necessary to make either Savannah or Brunswick the terminus of the route, in order that the barges arriving from the West may discharge their cargoes of grain directly into the vessels by which it is to be conveyed to Europe. The distance from Darien to Savannah, inside of the Sea Islands, is one hundred and fifty miles; from Darien to Brunswick, perhaps twenty miles. On either route a certain amount of canal would have to be built, the cost of which, in the absence of a detailed survey, it is not possible to give accurately, but which may be assumed at $50,000 per mile.

This completes the detailed description of the features of this scheme.

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RECAPITULATION.

Estimated cost of opening a line of water-communication from Cairo, Illinois, on the Mississippi River, to Brunswick, Georgia, on the Atlantic coast, by the way of the Ohio, Tennessee, Coosa, Etowah, Ocmulgee, and Altamaha Rivers and connecting canals, suitable for the passage of barges carrying 170 tons of freight, during the season of lowest water on those rivers, and 300 tons during the ordinary stages of the water.

		Distance by river.	Distance by canal and slack-water.	Estimated cost.
1	Ohio division	50		$45,000
2	Tennessee division	255		500,000
3	Muscle Shoals division		38	3,676,000
4	Alabama division	75		75,000
5	Sand Mountain division		50½	11,570,607
6	Coosa division	153½		100,000
7	Georgia division		211¼	20,435,684
8	Altamaha division	410	45	2,500,000
	To Brunswick, say		20	1,000,000
		943½	364¾	39,902,291
		364¾		
	Total length, (miles)	1,308		

The arguments and reasons which may be advanced in favor of opening this route need scarcely be more than alluded to here, for they have a common application to all the routes which have been or can be suggested for connecting our great grain-producing regions with our seaports, have formed a certain and unfailing subject of discussion at all the commercial conventions which have been held in this country for years, and have attracted the attention of nearly every board of trade and chamber of commerce of any consequence in the land.

This is quite sufficient to show that it is a real *necessity* which underlies this movement; a necessity born of the fact that the enormous increase of population in the valleys of the Mississippi and its tributaries has caused the production of grain to far outstrip the means of its transport. The old routes by water and rail are crowded to their fullest capacity, and either new routes must be found or the results of the farmer's labor must remain uselessly on his hands.

Beyond certain distances the cost of transportation to a market eats up the producer's profits and makes it useless for him to ship his crops. This occurs much more quickly by rail than by water, the cost of transportation by rail being from five to six times as much as by river, and about three times as much as by canal. In looking for new outlets for the grain-crops, then, water-routes are to be preferred.

The only water-outlets which the Mississippi Valley now has are the river itself and the canals, which connect it with the great lakes. The geographical positions of the Ohio and Tennessee Rivers, in relation to the rivers which flow into the Atlantic, will afford, however, at a comparatively moderate expenditure, two other outlets more direct than those by the Mississippi and the lakes, and possessing other advantages not enjoyed by either of these.

It is with the latter only that this report is concerned, and it may be said for it that while it enjoys every advantage possessed by the others, it is superior to them all in this, that it will never be obstructed by ice; will never be rendered impassable by drought; does not descend sufficiently low into the heated region to have its cargoes injured by heat or moisture; will require no rehandling of cargo between the points of shipment and discharge, and will cost but little more than the Erie Canal enlarged, while its capacity will be greater, and no doubt it will,

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like the Erie Canal, pay for original outlay, interest, expenses of repair, and service, with a large balance to its credit, in the course of thirty years.

Taking Saint Louis (which has become and is likely to remain the center of trade of the Mississippi Valley) as a starting point, the distance by this route to an Atlantic shipping-port, Brunswick, Georgia, is fifteen hundred and eight miles by careful measurement, three hundred and sixty-five miles of which consist of canal and slackwater navigation, and the remaining eleven hundred and forty-three miles of river navigation.

From Saint Louis to New York, by way of the Illinois and Michigan and Erie Canals, is nineteen hundred and sixty miles; and by way of the Portsmouth, Ohio, and Erie Canals, it is eighteen hundred and thirteen miles. These two distances are taken from the "Report of the committee of the National Board of Trade on a continuous water-line of transportation through Virginia;" printed at Richmond, Virginia, in 1869.

The difference of distance in favor of the Brunswick route to a port is three hundred and five miles, about one-sixth of the whole distance to New York, and as the saving in distance is entirely by river, over which the actual cost of transporting freight is about three mills per ton per mile, the saving of cost from this cause alone equals 91½ cents per ton. Three transfers of cargo are saved, which amounts to 30 cents a ton more; and as the Ohio route includes about three hundred miles more of canal than the Brunswick route, over which the difference of cost of transportation is not less than two mills per ton per mile = 60 cents, the total saving in cost by the Brunswick route, is $1.81½ per ton, or about 5½ cents per bushel.

I have not thought it necessary to enter into any elaborate comparisons of cost by the various routes, partly because I cannot be certain of river distances, map measurements being exceedingly deceptive, and invariably falling far short of the real distances; as, for instance, in the route under discussion, from Saint Louis to Brunswick, which has heretofore been reckoned at one thousand eighty-eight miles, instead of one thousand five hundred and eight miles, as it is, and upon which a number of calculations, of course deceptive in character, had been based.

Nothing has been said of the probable effect which the opening of this route could have upon the development of the exceedingly rich mineral region through which it passes; nor of its stimulating effect upon the energies of the people who have been impoverished, and, to some extent, disheartened by the trials of the late war; nor of the influence which commerce, the great peace-maker, would surely exercise in removing from the minds of citizens of different sections of our common country so brought into contact, the feelings of prejudice which too often prevent them from seeing how much there is in each other that deserves admiration and respect.

These are matters that pertain rather to the province of the statesman, than to that of the engineer, and to the statesman I leave their discussion.

I had hoped to incorporate in this report the statistics gathered by the last census bearing upon the subject of internal water communications, but I have not yet received them. I hope, however, to get them in time to insert them in my annual report for this year.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

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M 7.

CANAL TO CONNECT THE TENNESSEE AND COOSA RIVERS.

CHATTANOOGA, TENNESSEE,
March 30, 1872.

MAJOR: I have the honor to submit the following report on the survey of a canal to connect the Tennessee and Coosa Rivers, from a point near Guntersville, Alabama, on the Tennessee River, to a point near Gadsden, Alabama, on the Coosa River.

The field-work of the survey was begun on the 24th of October, 1871, and was continued through the succeeding months to February 13, 1872. Two routes were surveyed: the first beginning at the mouth of Short Creek, on the Tennessee River, two and a half miles above Guntersville, Alabama, following up that stream on a gradual ascent of Sand Mountain until near the summit; thence across the summit of the mountain to the head of Fisher's Creek, following Fisher's Creek as it descends the southeast side of the mountain through Fisher's Gap. When near the foot of the mountain the line leaves Fisher's Creek and passes along the slope of the mountain side to Sand Valley, and through Sand Valley to Line Creek; thence down Line Creek nearly parallel to the East Alabama and Cincinnati Railroad to Wills Creek; thence along the bank of Wills Creek to its junction with the Coosa River, two and a half miles below Gadsden, Alabama.

The summit-level of canal at the top of Sand Mountain is 9.8 miles in length and 400 feet above low water in Tennessee River near Guntersville, Alabama, and 464 feet above low water in the Coosa River near Gadsden, Alabama.

The estimate for this line includes the following general items, viz: three miles of slackwater on Short Creek, thirty-three miles of canal from slackwater on Short Creek to slackwater on Wills Creek, fourteen and a half miles of slackwater on Wills Creek, and fifteen miles of feeder from Town Creek to summit-level of canal. The line of levels on the two routes surveyed demonstrates that Town Creek is 144 feet higher than summit-level of canal on the Short Creek route, and that a feeder can be brought across the mountain from Town Creek. Accompanying this are tabular statements showing the various items, prices, and the estimated cost of each mile, and the total cost.

The survey of the second route commenced at the mouth of Town Creek, on the Tennessee River, two and three-fourths miles above Guntersville, Alabama, passing up Town Creek in an easterly direction on a gradual ascent for thirty-one miles; thence leaving Town Creek and passing across the summit of the mountain in a southeasterly direction, descending the southeast side of the mountain, through the Lebanon Gap and Sand Valley to Wills Creek; thence passing along the bank of Wills Creek to its mouth on the Coosa River, two and a half miles below Gadsden, Alabama. The summit-level of canal by this line will be four and a half miles long, extending from Town Creek across the mountain to Lebanon Gap, and will pass through a tunnel 6,300 feet long. The elevation is 544 feet above low water in Tennessee River near Guntersville, Alabama, and 608 feet above low water in Coosa River near Gadsden, Alabama. The elevation above summit-level of canal via Short Creek is 144 feet. The estimate for this line includes the following general items, viz: Ten miles of slackwater on Town Creek, thirty-four and a half miles of canal from slackwater on Town Creek to slackwater on Wills Creek, including 6,300 linear feet of tunnel.

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and forty-one and three-fourths miles of slackwater on Wills Creek. The accompanying tabular statement shows the various items, prices, cost of each mile, and the total cost.

The estimates are based upon a canal 56 feet wide at bottom, 70 feet wide at top-water, 5 feet least depth of water, two tow-paths 8 feet wide on top, 2 feet above water-surface, and locks 120 feet long between gates, and 30 feet wide. The estimate for slackwater includes locks of first-class masonry, and dams of rubble-masonry laid in cement, and a tow-path built along one bank, 12 feet wide on top. The item of clearing includes grubbing and the removal of snags and drift-wood from the streams when slackwater is used.

The accompanying maps show the topography on both sides of the line so far as the transit-man could observe in passing along the line. Having no topographer, the transit-man combined that with his other duties. The profiles show the surface of the ground on the lines surveyed, the surface of water in streams, the depth of water, and the grades of canal and location of locks.

The tabular statements show the cost of the work on that portion of the line crossing Sand Mountain to be much greater in proportion than the rest of the line; this is due to the great elevation to be overcome by lockage, and the heavy excavation which is for the most part in hard sandstone rock. The excavation in the valley will generally be in clay soil, easily worked. Rock for masonry in locks can be obtained in abundance all along the line, and is of the best quality. Clay for puddling is abundant in the valley; but on the mountain it is not so abundant; it is there to be found between ledges of rocks and will have to be mined. Not far from our line there is a manufactory of earthenware that uses this mountain clay, and they say it is entirely free from lime, and I think for puddling it is superior to the clay in the valleys.

Of the two routes I think the first one, via Short Creek, is the best for several reasons. First, it is shorter, being fifty and one-half miles, against eighty-six and one-fourth by the other route. Second, there will be no tunnel. Third, there will be 144 feet less elevation to be overcome by lockage. Fourth, the cost is less. It can be fed by bringing a conduit across the mountain from Town Creek, a distance of about fifteen miles. To be certain of having fall enough for the conduit I have laid the grade of the summit-level very low; and a careful location may make the cut lighter and lessen the cost of the work materially.

The supply of water in Town Creek, for feeding the canal, I found by estimation to be about 36,000 cubic feet per minute, or 51,840,000 per day during the months of December, January, February, March, and April. The surface area of thirty-three miles of canal is 12,196,800 square feet. Assuming the waste of water by evaporation, leakage of channel, and repairs to be one-sixth of a foot per day, as laid down by Professor Rankin, the quantity would be 2,032,800 cubic feet. The waste by current from the higher toward the lower reaches, produced by leakage at the lock-gates, will be about 30,000 cubic feet daily. Then the total waste of water daily would be 2,062,800 cubic feet; subtracting this from the daily supply, 51,840,000 cubic feet, the remainder will be 49,777,200 cubic feet, available for lockage. A lockful of water is 43,200 cubic feet; allowing three lockfuls or 129,600 cubic feet for each boat passing through, we have water for 384 boats; but as the capacity of a canal is limited to 200 boats daily, we have surplus water of 552 lockfuls.

During the months of November, May, and June, the water-supply will be about one-half what it was during the winter and early spring

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months, and after making the proper deductions for evaporation, leakage, &c., the available supply will be 552 lockfuls, and allowing three lockfulls to each boat, we have a capacity for 184 boats.

During the remaining four months of the year, July, August, September, and October, the supply will be very uncertain, probably not more than enough to supply the waste by evaporation, filtration, &c. To render the supply certain during this season, it will be necessary to construct store reservoirs to retain the excess of water during winter to be used as needed in summer.

A dam 50 feet high and 700 feet long across Town Creek, near Smith's mill, would form a reservoir of 405,000,000 cubic feet capacity. The cost would be about $184,064. Two other reservoirs could be constructed of about the same capacity and cost in the basin of Sweetwater Creek, a branch of Town Creek; and in the basin of Cross Creek, a branch of Short Creek. These three would cost $552,192, and would have a capacity of 1,215,000,000 cubic feet. The dry season would last about one hundred and twenty days, the daily supply would then be 10,125,000 cubic feet, or 234 lockfuls; allowing three lockfuls to each boat, the water supply would be sufficient for 78 boats daily, or, assuming the capacity of the canal to be 200 boats daily, not quite one-half the capacity of the canal.

I have not considered it a part of my duties to report upon the commercial advantages of this project, but have confined myself strictly to the estimates of the cost of construction. No estimate has been made for land damages, as the line runs a large part of the way through public lands, or through lands of little value, except in Wills Valley, where the right of way will probably be donated by land-owners.

I am indebted to my assistant, Mr. Martin Palmer, and my leveler, Mr. W. A. Toms, for efficient services, both in the field and in the office.

I have the honor to be your most obedient servant,

JAS. C. LONG,
Civil Engineer in Charge of Survey.

Major WALTER MCFARLAND,
Corps of Engineers, United States Army.

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Tabular statement showing the estimated cost of a canal 56 feet breadth at bottom, 70 feet breadth at top-water, and 5 feet least depth of water. Survey beginning at the mouth of Short Creek, on the Tennessee River, two and one-half miles above Guntersville, Alabama, ending at the mouth of Wills Creek, on the Coosa River, near Gadsden, Alabama. The first three miles are estimated for slackwater on Short Creek, and the last fourteen and one-half miles for slackwater on Wills Creek. Survey made in October and November, 1871, by J. C. Long, civil engineer, under direction of Major Walter McFarland, United States Engineers.

Miles.	Locks, 8 feet lift.	Amount.	Locks, 10 feet lift.	Amount.	Locks, 12 feet lift.	Amount.	Cubic yards culvert masonry.	Price.	Amount.	Cubic yards masonry in dams and weirs.	Price.	Amount.
1					1	$27,112 00	103.2	$6 00	$619 20	2,211	$8 00	$17,688 00
2							145	6 00	870 00			
3					1	27,112 00	61.2	6 00	367 20			
4					1	27,112 00						
5					4	108,448 00						
6					9	244,008 00						
7			1	$24,559 00	4	108,448 00						
8			4	98,236 00								
9			2	49,118 00								
10			2	49,118 00								
11			2	49,118 00								
12			1	24,559 00								
13			1	24,559 00								
14												
15			2	49,118 00								
16												
17			1	24,559 00								
18												
19							445	6 00	2,770 00			
20							196	6 00	1,176 00			
21												
22												
23												
24												
25												
26												
27					7	189,784 00						
28					10	271,120 00						
29					6	162,672 00						
30												
31												
32					5	135,560 00						
33					4	108,448 00						
34			1	24,559 00								
35	1	$25,006 50										

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Tabular statement showing the estimated cost of a canal to connect the Tennessee and Coosa River, &c.—Continued.

Miles.	Locks, 8 feet lift.	Amount.	Locks, 10 feet lift.	Amount.	Locks, 12 feet lift.	Amount.	Cubic yards culvert masonry.	Price.	Amount.	Cubic yards masonry in dams and weirs.	Price.	Amount.
36	1	22,006 50					93.6	$6 00	$561 60	1,133	$8 00	$9,064 00
37	1	22,006 50					60	6 00	360 00			
38							171.4	6 00	1,028 40	1,133	8 00	9,064 00
39	1	22,006 50					72	6 00	432 00			
40							127.6	6 00	765 60			
41							224	6 00	1,344 00	1,133	8 00	9,064 00
42	1	22,006 50					111.6	6 00	669 60			
43							73	6 00	438 00	1,133	8 00	9,064 00
44	1	22,006 50					104.4	6 00	626 40			
45							139	6 00	834 00			
46							100	6 00	600 00	1,133	8 00	9,064 00
47	1	22,006 50					230.6	6 00	1,383 60			
48							226.6	6 00	1,359 60	1,133	8 00	9,064 00
49	1	22,006 50					221	6 00	1,326 00			
50							134	6 00	804 00	1,133	8 00	9,064 00
1	1	22,006 50										
Total	9	$198,058 50	17	$417,503 00	52	$1,409,824 00	3,039.2	.....	18,235 20	10,142	.....	81,136 00

Miles.	Cubic yards rock excavation.	Price.	Amount.	Cubic yards earth excavation and embankment.	Price.	Amount.	Cubic yards of puddling-clay.	Price.	Amount.	Miles of clearing.	Price.	Amount.	Amount per mile.
1				140,294	$0 35	$49,102 90				1	$1,500 00	$1,500 00	$96,022 10
2				99,490	35	34,821 50				1	1,500 00	1,500 00	37,191 50
3	6,504	$1 50	$9,756 00	18,720	35	6,552 00	688	$1 00	$688 00	1	1,500 00	1,500 00	45,975 20
4	83,892	1 50	125,838 00	38,666	35	13,533 10	6,140	1 00	6,140 00	1	500 00	500 00	173,193 10
5	192,616	1 50	288,924 00				6,225	1 00	6,225 00	1	500 00	500 00	404,127 00
6	197,509	1 50	296,263 50				6,409	1 00	6,409 00	1	500 00	500 00	547,180 50
7	128,185	1 50	192,277 50				4,803	1 00	4,803 00	1	500 00	500 00	330,587 50
8	96,993	1 50	145,489 50	8,641	35	3,024 35	5,850	1 00	5,850 00	1	500 00	500 00	253,009 85
9	48,614	1 50	72,921 00	16,198	35	5,669 30	3,925	1 00	3,925 00	1	500 00	500 00	132,133 30
10	62,150	1 50	93,225 00	20,715	35	7,250 25	4,835	1 00	4,835 00	1	500 00	500 00	154,928 25
11	79,162	1 50	118,743 00	14,054	35	4,918 90	4,211	1 00	4,211 00	1	500 00	500 00	117,140 90
12	44,067	1 50	66,100 50	11,267	35	3,943 45	3,919	1 00	3,919 00	1	500 00	500 00	79,473 25

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13	[illegible]	1 50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 00	[illegible]	1	500 00	500 00	75,973 05
14	31,680	1 50	51,375 00	14,175	35	6,018 75	3,518	1 00	3,718 00	1	500 00	500 00	61,821 25
15	36,249	1 50	54,445 00	18,120	35	6,342 00	3,971	1 00	3,971 00	1	500 00	500 00	114,276 00
16	24,627	1 50	35,455 50	21,493	35	7,522 55	3,645	1 00	3,645 00	1	500 00	500 00	47,123 05
17	23,163	1 50	34,744 50	23,163	35	8,107 05	3,806	1 00	3,806 00	1	500 00	500 00	71,806 55
18	11,005	1 50	16,507 50	31,687	35	11,090 45	3,694	1 00	3,694 00	1	500 00	500 00	31,791 95
19	12,874	1 50	19,311 00	38,622	35	13,517 70	4,021	1 00	4,021 00	1	500 00	500 00	40,019 70
20	26,419	1 50	39,628 50	79,273	35	27,745 55	4,380	1 00	4,380 00	1	500 00	500 00	73,430 05
21	15,113	1 50	22,669 50	45,339	35	15,868 65	4,415	1 00	4,415 00	1	500 00	500 00	43,453 15
22	12,512	1 50	18,768 00	37,536	35	13,137 60	4,189	1 00	4,189 00	1	500 00	500 00	36,594 60
23	85,418	1 50	128,127 00										128,627 00
24	409,634	1 50	614,451 00							1	500 00	500 00	614,951 00
25	715,859	1 50	1,073,788 50							1	500 00	500 00	1,074,288 50
26	879,849	1 50	1,319,773 50							1	500 00	500 00	1,320,273 50
27	573,664	1 50	860,496 00	3,664	35	1,282 40				1	500 00	500 00	1,052,062 40
28	21,898	1 50	32,847 00	21,898	35	7,664 30				1	500 00	500 00	312,131 30
29	46,378	1 50	69,567 00	46,378	35	16,232 30				1	500 00	500 00	248,971 30
30	34,295	1 50	51,442 50	34,295	35	12,003 25				1	500 00	500 00	63,945 75
31				30,394	35	10,637 90							10,637 90
32				59,302	35	20,755 70							156,315 70
33				52,908	35	18,517 80							126,965 80
34				38,589	35	13,506 15							38,065 15
35				48,885	35	17,109 75							39,116 25
36				38,506	35	13,477 10				1	500 00	500 00	35,983 60
37				7,162	35	2,506 70				1	1,500 00	1,500 00	35,638 80
38				14,181	35	4,963 35				1	1,500 00	1,500 00	6,823 35
39				26,727	35	9,354 45				1	1,500 00	1,500 00	42,953 35
40				9,901	35	3,465 35				1	1,500 00	1,500 00	5,397 35
41				35,269	35	12,344 15				1	1,500 00	1,500 00	14,609 75
42				45,895	35	16,063 25				1	1,500 00	1,500 00	49,977 75
43				43,967	35	15,388 45				1	1,500 00	1,500 00	17,558 05
44				38,767	35	13,568 45				1	1,500 00	1,500 00	46,576 95
45				41,620	35	14,567 00				1	1,500 00	1,500 00	16,693 40
46				38,989	35	13,646 15				1	1,500 00	1,500 00	15,980 15
47				20,223	35	7,078 05				1	1,500 00	1,500 00	40,248 55
48				43,975	35	15,391 75				1	1,500 00	1,500 00	18,274 85
49				37,863	35	13,252 05				1	1,500 00	1,500 00	47,182 15
50				58,948	35	20,631 80				1	1,500 00	1,500 00	23,457 80
½				21,583	35	7,554 05				½	1,500 00	1,500 00	40,178 55
Total	3,879,356		5,809,034 00	1,556,243		544,685 05	86,432		86,432 00	50½		40,250 00	8,615,157 75
Add for fifteen miles of feeder from Town Creek, at $30,000 per mile													450,000 00
Add 5 per cent. for engineering and contingencies													453,257 92
Total cost													9,518,415 67

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WALTER McFARLAND, *Major of Engineers.*

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M 8.

GEORGIA CANAL SURVEY.

CHATTANOOGA, TENNESSEE,
May 7, 1872.

SIR: I have the honor to present the following report on the Georgia Canal survey, made in obedience to your letter of appointment and accompanying instructions of the 24th of October, 1871.

In accordance therewith I repaired at once to Atlanta, and began the organization of a party. In the mean time I called upon the State engineer and superintendent of public works, (Colonel B. W. Frobel,) who kindly furnished me with all the information in his office touching upon the subject, and gave me complete maps, statistics, &c., which were very important in aiding me to determine upon the general plan of survey, as well as the probable route to be examined.

November 2 I began the reconnaissance at Du Luth, a station on the Atlanta and Richmond Air-Line Railroad, twenty-five miles east of Atlanta, and proceeded across the country to the Etowah River. Establishing the initial point of survey on the Etowah, at the mouth of a small stream called Owl Creek, the examination was conducted up the Etowah River to the mouth of Little River. Thence up this stream to the mouth of Merritt's Creek, (Rocky Creek,) to the summit of main ridge dividing the waters of the Etowah from those of the Chattahoochee. From this ridge it appeared quite apparent that no definite idea as to a feasible line could be arrived at, except by a tedious instrumental examination, as a broad, broken plateau presented itself for a distance of some thirty miles, passing across it diagonally, as it seemed necessary to do in order to effect a reasonable crossing at the Chattahoochee River, which lies deeply embedded in this elevated table-land. Having decided on the line from the Etowah River to the summit of the dividing ridge above stated, the engineer party was moved to the vicinity of the mouth of Little River, and the instrumental examination began at the mouth of Owl Creek, in Cherokee County, on the 10th day of November, 1871. From this point the adopted line passes up the immediate valley of the Etowah to the mouth of Little River; thence up Little River to the mouth of Merritt's Creek; thence up Merritt's Creek to station 954 of the survey, the point at which the summit level of the canal-cutting crossing the plateau begins. This portion of the line is designated as the Little River section.

The distance from Owl Creek to the mouth of Little River is 4.11 miles, and from mouth of Little River to summit-level is 16.91 miles, making the total distance of this section 21.02 miles. The canal-level at mouth of Owl Creek above tide is 798 feet, and at summit-level 1,008 feet, leaving a difference of 210 feet to be overcome by locks.

The rivers on this section are quite tortuous, the valleys narrow, and frequently closely bounded by steep rocky cliffs, with frequent long stretches, however, of favorable bottom, low table-land, and gentle side-hill slopes. The soil is a red-clay base, with sand and gravel on top, and generally favorable for the retention of water. Stone of the granite formation will be found in sufficient quantities for the demands of construction, and it appears to be of good quality. The supply of water for 16.91 miles of this section will be afforded by Little River and its tributaries, which will be sufficient, except in summer droughts, when the supply for the summit-level must make up any deficit, or reservoirs may be cheaply constructed at a number of points, and the waters

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gathered and held in reserve in ample quantities to meet the necessities of such a contingency.

The Etowah, having its sources in the Blue Ridge, from seventy-five to one hundred miles above the mouth of Little River, and draining by its many tributaries an area not less than one thousand square miles, will afford at all seasons an abundant supply of water for the canal lying contiguous. If there were any doubt upon this point, it is apparent, without consuming time for an examination, that within this large area must be many favorable points for the construction of reservoirs at very small cost. But I do not believe the necessity for this is likely to arise. This section, then, of 21.02 miles, is estimated to cost for a canal 70 feet width at surface, 56 feet at bottom, and 5 feet depth of water, with tow-paths on each side 8 feet wide at top, and embankment and excavation slopes of 1½ feet horizontal to 1 foot perpendicular, $1,051,000, exclusive of the locks only.

CHATTAHOOCHEE SECTION, 33.08 MILES LONG.

Next in order comes the Chattahoochee section, the canal-level of which is 1,008 feet above tide, and length 33.08 miles, ending at station No. 2691 of the survey, and at the eastern base of the Peach-tree Ridge. This ridge separates the Gulf from the Atlantic waters, and presents a favorable location for the Atlanta and Richmond Air-Line Railway.

The Chattahoochee section presented by far the most formidable difficulties to the survey, as no line could be indicated from the reconnaissance. Hence we had to feel our way across this rugged plateau with our instruments, and the result, while it has demonstrated that a feasible line exists, proves conclusively, too, that it must be obtained at heavy cost, and yet probably not beyond what might reasonably be expected from an inspection of the topography of the country. This section from a point near its beginning pierces the ridge dividing Etowah and Chattahoochee Rivers, at Mrs. Alberson's, in Milton County, with a tunnel 3,200 feet long, with the base 110 feet below the crest or summit, and heavy approaches, 60 feet in depth at the portals. The line thence emerges upon the waters of the Chattahoochee, following a small branch about one and a third miles to Fanguilla Creek; thence down Fanguilla one and a half miles, where it leaves this stream and crosses the ridge to Smith's Creek; thence down Smith's Creek a short distance, when it leaves it and makes pretty directly for the crossing of Vickery's Creek at a point one-half to three-fourths of a mile above the mouth of Long Indian Creek. The canal-level or bottom of aqueduct at Vickery's Creek is 52 feet above surface of water. Cutting 40 feet at the gap in the ridge at Webb's, we pass to the gentle slope of Long Indian Creek, and continuing up it passes through the ridge dividing Long Indian from John's Creek at a low gap at Esquire Pates's. Low, apparently, as is this gap, the depth of cutting (at summit) is 69 feet. Continuing, it passes along the spurs of a deep gorge to the slope of John's Creek, crossing the Du Luth and Alpharetta road at William Martin's. Ascertaining here that our elevation is 100 feet or more above the water of John's Creek, and the valley broad, we are forced to continue up John's Creek, crossing the numerous spurs and ravines, until we effect an eligible crossing of the same at Abbott's mill, 42 feet above the water.

The line continues on the left slope of the high grounds on the right, and crosses a spur of the main ridge, and the Atlanta and Dahlonega road one-half mile south of Mrs. Taylor's, and crossing a small branch passes through the main ridge, dividing the waters of John's Creek and the Chattahoochee. The cutting at this summit is 50 feet.

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Having passed this ridge we stand upon the immediate slope of the Chattahoochee some two miles distant from the stream, and at an elevation of not less than 130 feet above its water. The valley is wide, and no high natural approaches by which we can reach it. But one alternative remains. We must and do ascend the rugged slope, cutting through the heavy spurs and filling the deep gorges and small streams until we approach the river, one-quarter mile above Terry's Ferry. In the mean time we have crossed Dick's Creek, near Moore's mill, 70 feet above the water, and made three heavy cuttings. The first, near Kelley's, is 59 feet in depth at summit and 2,200 feet long. The second, at Harris's, is 69 feet, and 1,500 feet long. The third, near Mrs. Jackson's, is 77 feet at summit and 2,600 feet long. The depth of these cuttings, as above stated, is the deepest point in the excavation, and gradually diminishes on either side until they pass into the embankment.

Having approached the Chattahoochee, one-quarter mile above Terry's Ferry, a thorough reconnaissance has determined that we have reached the most favorable point at which to effect a crossing. The heights on the western slope are particularly favorable, while on the opposite bank the hills recede. An admirable solid-rock bottom stretches entirely across the stream, affording an unyielding and imperishable foundation for the masonry of the heavy aqueduct to be constructed.

We cross then the Chattahoochee at this point, and find our canal-level on the topmost points of the heights in Gwinnett County. We have passed at an elevation of 117½ feet above the surface of water, and the total length of aqueduct and embankment approaches is 1,900 feet. The aqueduct, to be constructed of the best granite, has three arches, and is 375 feet long. The width of water is 30 feet at the bottom of chamber, and depth 5 feet. The quantities and estimate of cost are as follows:

Estimate of cost of Chattahoochee aqueduct.

800,000 cubic yards earth embankment in the approaches, at 50 cents	$400,000 00
3,300 cubic yards stone-masonry in arches, at $25	83,250 00
16,846 cubic yards stone-masonry in piers, spandrels, chamber-walls, &c., at $15	252,690 00
Coffer-dams, foundations, and centering, including contingencies	25,000 00
Total	760,940 00

Having crossed the Chattahoochee, the line passes very directly through the knobs to the slope of Level Creek, and up to a crossing of the same at Hope Brogdin's. In passing the ridge between Chattahoochee and Level Creek a cutting is made 52 feet deep at the crest and 1,400 feet long. The elevation of canal at the crossing of Level Creek is 46 feet above the water. It not being possible to cross the high ridge dividing Level Creek from the waters of the Suwanee, we are forced out of the natural direction and have to bear almost due south, along the eastern slope of Level Creek, to find a practicable crossing of the ridge above alluded to. This crossing is made at a gap about one and one-fifth miles almost due north from Suwanee depot, on the Atlanta and Richmond Air-Line Road. The depth of this excavation is 73 feet at the summit, and 3,000 feet long. Thence the line continues very direct to the Atlanta and Richmond Air-Line Railway, crossing it 26 feet beneath the rails, and about 3,000 feet northeast of Suwanee station. At this point we have just gained the crest of the slope of Suwanee Creek, which lies directly before us, deeply burrowed among the high, rough, and rugged rolling lands on either side of it. And, too, its elevation is

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110 feet beneath our canal level, the valley broad, and no high approaches favoring a crossing. Again we resort to the only hope of escape from this dilemma, that of passing up the western slope, cutting again and again the spurs and filling the ravines until we reach a crossing which is found about one mile above the mouth of Ivy Creek, and at an elevation of 66 feet above the surface of the water.

From the crossing of Suwanee the line turns to the right, and passing down on the eastern slope, it turns the end of the ridge dividing Suwanee and Ivy Creeks, and continuing up the northern slope of the latter, crosses it about one and a half miles above its junction with the Suwanee, and 68 feet above the water-level, and thence continues along the northern slope of a small stream which heads at the western base of Peach Tree Ridge, at Patrick O'Rourke's, and passes through this ridge at the depression familiarly known as the "Big Poplar." This ridge divides the Chattahoochee from the Ocmulgee waters, or rather, it is the ridge dividing the waters of the Gulf of Mexico from the drainage of the Atlantic slope. Cutting through this obstruction with a summit-depth of 68 feet and 5,400 feet long, we have reached the eastern limit of the summit-level, or Chattahoochee section, and find ourselves on the waters of the Ocmulgee. This small stream is known by the significant appellation of "Ague Creek," and is a tributary of the Yellow River. The section of 33.08 miles, just described, is the summit-level in the Georgia Canal project. The canal-level or water-base, for this entire distance, is 1,008 feet above tide-water. The configuration of country traversed by this section has been minutely described. It, as well as the Little River section, lies wholly within the gold-region of North Georgia, and their extreme terminal limits may be regarded as defining the west and east boundary of this golden field. The stone formation is that of granite, with surface indications of an excess of mica. This renders the stone soft and friable, and doubtless many of the excavations will have a large percentage of such material, and considerable even harder. There are many indications of solid, compact granite, quite sufficient, doubtless, to meet all the necessities of construction. Then there are occasional outcrops of the purest white quartz. The soil is a red and yellow clay, more or less interspersed with small gravel, and well adapted to the construction of an artificial water-channel. The cuttings along the line of the Air-Line Railroad do not expose a large amount of rock. Indeed, it is remarkable how little is developed, and what is, is of the soft, friable texture above described. But in order that an underestimate shall not be presented, a liberal allowance has been made for rock in the cuttings, and I feel sure that the estimate presented will amply cover the cost.

Having developed a practical canal-line across this plateau, susceptible of being substantially constructed for a given number of dollars, the next question of importance is, can it be abundantly supplied with water, to meet all the demands of a heavy traffic, such as may reasonably be expected to pass over it? Yes; the Chattahoochee alone will furnish the supply, but it will have to be tapped at a point about forty miles above the aqueduct, and the water brought down through a "feeder" to be constructed. Levels were taken from the Air-Line Railroad at a point about eight miles above Gainesville, and transferred to the Chattahoochee at the foot of "Bates Shoal." The elevation of the river at that point was found to be 1,016.66 feet above tide, or 8.66 feet above the summit-level of the canal. From the foot of Bates Shoal to mouth of Mud Creek is 6.5 miles, and the probable fall not less than 8 feet per mile. The mouth of Mud Creek, by the meanderings of

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the river, is forty miles from the aqueduct at Terry's Ferry, and this distance would be the approximate length of the main feeder, from the mouth of Mud Creek to the summit-level. By this estimate, the fall from the source of the feeder to the canal-basin would be 60 feet, or a fall at the rate of 1.5 feet per mile. This amount of fall will probably be required in order to furnish the necessary supply of water. A cross-section and gauge of the Chattahoochee at Warsaw Ferry gave 1,500 cubic feet per second as the probable quantity. The Chattahoochee at the mouth of Mud Creek has a capacity of probably not less than half this amount, or 750 cubic feet per second. It will require 54,885,600 cubic feet to fill the summit-level. A supply of 200 cubic feet per second would fill the summit-level of 33.08 miles in about 76 hours, not taking into the account the leakage, absorption, and evaporation. But there is a large tributary of the Chattahoochee, the Chestatee River, the mouth of which is about 18.1 miles above the aqueduct over the Chattahoochee. If necessary, this large and constant mountain-stream may be carried into the main feeder. Then we may use for the same purpose, at small expense, Vickery's, John's, Dick's, Suwanee, and Ivy Creeks, all considerable little streams. The area drained by the Chattahoochee, available for purposes of supply, is probably not less than seven hundred and fifty square miles. It appears, then, not only that there is a supply of water for the summit-level, but that there is a superabundance, and it may be made constant and never-failing.

Estimate of tunnel, 3,200 feet long.

173,866 cubic yards excavation, at $6 per cubic yard	$1,043,196 00
29,629 cubic yards masonry, at $12 per cubic yard	355,548 00
Total	1,398,744 00
Add the estimate for Chattahoochee aqueduct	760,940 00
Add 40 miles of feeder, at $25,000 per mile	1,000,000 00
Add 32 miles of main line, at $125,000 per mile	4,000,000 00
Total cost of Chattahoochee section	7,159,684 00

YELLOW RIVER SECTION, 58.62 MILES.

This portion of the canal-line extends from the end of the Chattahoochee section, on the head-waters of Ague Creek, to the mouth of the South River. The union of the Yellow and South Rivers forms the Ocmulgee. This section is 58.62 miles long and lies wholly in the immediate valley of Yellow River. The counties through which it passes are Gwinnett, De Kalb, Rockdale, and Newton. The towns near the line are, Lawrenceville, two miles; Stone Mountain, five miles; Conyers, two and a half miles, and Covington, three miles distant. This river also is very tortuous, presenting many abrupt turns, with high, sharp spurs jutting in, and frequent rock cliffs, particularly for from ten to fifteen miles in the vicinity of Stone Mountain. The causes which seem to have upheaved this rare mountain phenomenon have disturbed the country adjacent for some distance around; hence the rough character of the Yellow River just described. On this section will be found the finest quality of granite in inexhaustible quantities. The principal tributaries of Yellow River are, Sweetwater, Rowland, Pew's Mountain, Little Mountain, Haynes, Gun, Hurricane, Beaver Dam, Turkey, and Dried Indian Creek. In addition, there are numerous smaller streams, bringing to the main channel a constant supply of pure mountain water. It is possible, however, that the first twelve miles to the mouth

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of Sweetwater Creek will have to be supplied in part from the supply at the summit-level, or, if found preferable, independent reservoirs may be constructed among the heads of the Yellow River at trifling cost. A mere inspection of the hydrographic system delineated on the maps of the county surveys will impress any one with the belief that the supply of water is ample. If, then, the question of a supply of water for this first twelve miles is decided in the affirmative, then is it settled from the mouth of Sweetwater to Macon, Hawkinsville, or at which point the terminus of the artificial water-line may be determined, for the volume is ever increasing in quantity, from the numerous, and many of them large, natural feeders. The fall in the canal-levels on this section is 465 feet, to be overcome with locks. The estimated cost, exclusive of locks and feeders, in round numbers, is $2,931,000.

OCMULGEE SECTION, 45.48 MILES.

This division of the line extends from the mouth of South River to Macon, and lies in the immediate valley of the Ocmulgee River, passing through Butts and Monroe Counties, and a part of Bibb. The principal tributaries of the Ocmulgee River, above Macon, are the Tussahaw, Yellow-water, and Sands Creeks, Towaliga River, Rum and Beaver Dam Creeks on the west slope, and Alcovy River and Falling Creek on the east. This section has all the characteristics of the Yellow River section, but in a favorably modified form. The river is much straighter, the bends less abrupt, and the rock-cliffs not near so numerous. As a general rule, the slopes are gentle, with a deep red-clay formation, admirably adapted to the purposes desired. The rock-formation is of the best quality of granite, and convenient quarries are to be found suitable for all the demands of the work. Indeed, the Ocmulgee Valley, generally, presents a very favorable location for the canal. The length is 45.48 miles, and estimated cost, $2,274,000, exclusive of locks and feeders. The elevation above tide of the surface of the Ocmulgee, at Macon, is 273 feet. Assuming the canal-level at 303 feet, if its terminus is taken farther down the river, and we have 240 feet vertical fall in the canal-levels from the mouth of South River to Macon, which height must be overcome by locks. The area drained by the waters of the Ocmulgee, above Macon, is not less than 2,400 square miles. The recorded annual rain-fall at Macon for the year 1871 equals 69.20 inches. The least amount was for the month of July, 1.64 inches, and the greater amount fell during the month of September, 11.96 inches. I have not been able to procure the annual rain-fall in North Georgia, nor, indeed, at Macon, except for the year 1871, and for the first quarter of 1872, which equals 21.97 inches.

RECAPITULATION.

Little River section, 21.02 miles, estimated cost	$1,051,000 00
Little River section, 210 feet vertical of lockage, at $2,500 per foot	525,000 00
Chattahoochee section, 33.08 miles, estimated cost	7,159,684 00
Yellow River section, 58.62 miles, estimated cost	2,931,000 00
Yellow River section, 465 feet vertical of lockage, at $2,500 per foot	1,162,500 00
Ocmulgee section, 44.48 miles, estimated cost	2,274,000 00
Ocmulgee section, 240 feet vertical of lockage, at $2,500	600,000 00
Allowance for additional feeders and reservoirs	1,000,000 00
Total distance, 158.20 miles; total estimated cost	16,703,184 00

This estimate is based upon a scale of liberal prices, and the quantities and classification of material, from estimates in detail, of full average portions of the different sections. It is sustained from close obser-

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vation of the general character of the country as the survey progressed, and I feel sure, in presenting it, that you have been furnished with a sum rather in excess than under the actual cost. It must be apparent to every one at all familiar with such subjects that these preliminary examinations cannot be regarded as even approximating a definitive location. On the contrary, the sum set apart to this work, and the time given in which to perform it, admitted of the tracing of one continuous line only. It has established in my mind one indelible fact, however, that the Georgia Canal project is feasible, and that on the line as developed it can be substantially constructed for the above amount, or, say, in round numbers, $17,000,000.

This survey being the pioneer operation of this great work, a broad field to explore yet lies before the engineer before a location can be entered upon and the work of construction begun. We have learned enough, however, of the topographical and hydrographic features of the country traversed to have formed a pretty clear opinion as to the direction in which to look for improvements. Standing at our initial point and looking toward the terminal, we must confine future preliminary examinations to the right, for it is in this direction alone that we can hope to shorten the distance, while on the left the country is too elevated to effect anything in the way of material improvement. The chief obstacles to a divergence to the right will be found in crossing the ridge dividing the Etowah and Chattahoochee Rivers, and the crossing of the Chattahoochee. But assuming that no material departure can be made from the present line, then there remains quite a large labor to perform in the perfecting of it. A great many advantages are to be taken of the country, in the location, and many modifications to be made, and generally for the better.

This closes the report on the Georgia Canal survey, and I now proceed to give you the result of reconnaissance of the Etowah River, made in accordance with your written instructions, dated March 11, 1872.

REPORT ON THE RECONNAISSANCE OF THE ETOWAH RIVER.

We closed the survey at Macon March 20, 1872, disbanded the party, and returned at once to Atlanta to close accounts and forward camp outfit to Chattanooga. As soon as this work was completed we started to our beginning, at Owl Creek, on the Etowah, and began the reconnaissance on the morning of the 29th of March; and now follows a copy of the field-record:

The river, one-fourth mile below the mouth of Owl Creek, getting narrower, is averaging from 40 to 50 yards in width, and is apparently deep enough for light-draught boats, say from 4 to 8 and 10 feet, and deeper.

One and a half miles below the mouth of Owl Creek there is a shoal extending across the river and 40 yards long. Two or three small shoals more in the first four miles. Four miles below Owl Creek the river widens to a width of from 100 to 120 yards, getting apparently shallower, and at four and a half miles a shoal 100 yards long begins, which would be expensive to take out. A lock and dam, probably, would be the best. This shoal ends below Mr. Thompson's place, where the river makes a sudden bend to the right. Probable fall of this shoal, 14 feet. From the ferry below Thomas's, water apparently from 6 to 10 feet for half a mile; thence, shoals for four to four and a half miles, to a point three-fourths of a mile below Cooper's iron-works. From here the river contracts to 60 or 70 yards wide, with depth to the Western and Atlantic Road apparently sufficient for navigation. At this point the

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river is 100 to 110 yards wide and 60 feet beneath the rails or grade of the railroad. Cartersville is two miles from the river, on our right. McChatchus's mill-dam, some 250 yards below the bridge, is 6 feet high, and it is lightly shoaly for 150 yards farther down. This would have to be overcome by another lock and dam. Four hundred and fifty yards below the mill is Puckett's Ferry, and a short distance below it another shoal extending across the river. This shoal is short, and could be improved at small expense. From one-fourth to one-half a mile below Puckett's Ferry is Napoleon Tomlin's mill, with dam 8 feet high. This will require another lock and dam. From this four or five miles forward, the average width of river is from 100 to 110 yards, and depth from 6 to 10 feet, except at from eight to ten short shoals of bowlder-formation, which could be removed at small expense. The water on these shoals varies (at the ordinary stage of water) from 1 to 3 feet in depth. We pass a new lattice-bridge on stone piers, which would have to be remodeled to meet the necessities of navigation. At Rowland's Ferry, from three to four miles from Cartersville, we begin the examination in a canoe, having been on foot from the beginning to this point. Half a mile below Rowland's Ferry is the Howe-truss bridge, of the Cartersville and Van Wert Railroad, which also would require modification.

Shelmon Shoal, one-fourth of a mile long, and river 80 to 100 yards wide, bottom mostly gravel. One and a half to two miles below, another shoal about 100 yards long, with some shoaly points intermediate, where in extreme low water the river would not exceed two feet in depth.

One mile farther, another shoal one-fourth of a mile long, and one-half to three-fourths of a mile still farther on, another shoal 100 yards long. This brings us to a burned bridge, name unknown. Below the bridge deep water and sand bottom; another shoal, 600 to 700 yards long; another mile and again a shoal 100 to 150 yards long; then two more and similar shoals, and we reach Dent's Ferry.

Half a mile below the ferry, a shoal 250 yards long. Two to three feet of loose rock and gravel taken out will sufficiently deepen the channel. Now we have deep water from 8 to 11 and 12 feet. Two miles farther on, through a bend to right, and we arrive at Hardin's Ferry, and immediately below, a shoal 350 yards long, which can be overcome only by locks and dams. The valley, getting narrower from Dent's Ferry, is confined more closely by rocky bluffs. Average width of river from 120 to 140 yards. One mile below Hardin's Ferry, the valley opens out gently on the left, rocky bluffs on the right. One-fourth to one-half mile farther, a shoal half a mile long, and solid rock bottom. Would require another dam and lock here. About one mile farther and another shoal 100 to 150 yards long, with width of river 100 to 120 yards. Shoaly at intervals for 400 to 500 yards, and for one-fourth of a mile more shallow water with gravel and sand bottom. Valley gradually widening. Now more shallow water, more or less shoaly, and one distinct rocky shoal, in all from one-fourth to one-half a mile long. Two and half miles farther, or about one and one-fourth miles below Wooley's Bridge, some shoaly places, extending, with intervals, for one-fourth of a mile, with gravel and sand bottom. Width of river, 100 yards. Opposite Captain Murchison's shoaly for three-fourths of a mile. This is called Ravenel's Shoal. To make it navigable a lock and dam would be necessary. Half a mile below this shoal is Taylor's Ferry, and five miles below the ferry is Ayer's Shoal, one-fourth of a mile long. The Rome and Kingston Railroad occupies the right bank at three or four miles below Taylor's Ferry. We now pass Evan's steam saw-mill

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and also his ferry. One-fourth of a mile below ferry, shallow water, from 3 to 4 feet now. Half a mile farther another shoal, and still below, shoaly river with gravel bottom. Five miles farther, Spring Creek comes in on the left. Half a mile below the mouth of creek, another heavy but short shoal, with width of river from 100 to 120 yards. Then we pass several shoaly places with gravel bottom, and, a mile or so farther, another short shoal. Half a mile farther Dyke's Creek enters on the right, and just below it the river is shoaly for 200 to 300 yards. Not far from the last, another short shoal, and after it shallow water with gravel bottom. At 400 to 500 yards below the shallow water another short shoal. A few more slight shoals, and at from one to one and a half miles farther a short shoal and a small island. From this to Rome, from two to two and a half miles, good water, and river from 100 to 120 yards wide.

Such are the field-notes of the reconnaissance of the Etowah River. Aside from the numerous shoals, the soundings gave only about from 3 to 4 feet in depth for about one-fourth the entire length of the river. I assume that the water was at least 2 feet higher than low summer water. It would be exceedingly difficult to make anything like a correct estimate from the data obtained for an improvement, available at all seasons, for the passage of light-draught steamers. This cannot be done without a careful survey; certainly not without a careful reconnaissance at the lowest stage of water. The examination did not impress me favorably as to the improvement of the Etowah adequate to the passage of small steamers.

Fearing that we might not find the river adapted to steam-navigation, at a reasonable cost, we kept a close observation on the valley on either side, in order to form an opinion as to the cost and feasibility of extending the canal to Rome, and it affords me pleasure to state that I regard the Etowah Valley most favorable for the purpose, and while I do not venture to decide that the river-improvement is not the best, yet, to be on the safe side, I unhesitatingly recommend that the estimate presented shall be for the continuation of the canal from the mouth of Owl Creek to Rome, a distance of fifty-three miles by river.

The area drained by the Etowah, from Rome to the mouth of Owl Creek, is not less than one thousand square miles. The character of the soil generally is that of a deep red and brown limestone clay. The rock-formation from Owl Creek to Cartersville is granitic, and from Cartersville to Rome, limestone, both existing in sufficient quantities for all the demands of construction. With the exception of four miles of rough work through the Allatoona Hills above Cartersville, there will be but a small percentage of cliff-cutting on the line. Indeed, I regard this as the most favorable section on the entire line included in this examination, except perhaps the Ocmulgee section, and the average cost per mile found necessary for the others will, I am confident, cover the cost of this. It is proper to state that this average of $50,000 per mile is obtained from the estimate in detail of a full average mile of the Yellow River section, which is the heaviest per mile of all the sections except the Chattahoochee, and is to be found in detail as follows:

Estimate of one full average mile of the Yellow River section.

45,397 cubic yards earth excavation, at 30 cents per cubic yard	$13,619 10
6,485 cubic yards loose rock excavation, at 55 cents per cubic yard	3,566 75
7,411 cubic yards solid rock excavation, at $1.40 per cubic yard	10,375 40
44,274 cubic yards borrowed embankment, at 22½ cents per cubic yard	9,961 65
1,125 cubic yards box-culvert masonry, including paving, at $4.50 per cubic yard	5,062 50

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200 cubic yards small aqueduct and arch-culvert masonry, at $15 per cubic yard	$3,000 00
Clearing and grubbing per mile	400 00
Land-damages	250 00
Road-bridging, farm-crossings, and contingencies per mile	3,764 60
Total cost of one full average mile	50,000 00

Applying, then, this average of cost to the Etowah section, as I did to the other sections, except the Chattahoochee, and we have the following estimate from Owl Creek to Rome:

Estimated cost of the Etowah section, 53 miles long.

53 miles of canal, at $50,000 per mile	$2,650,000 00
One aqueduct over the Etowah	350,000 00
293 feet vertical of lockage, at $2,500 per foot	732,500 00
53 miles total distance; total cost	3,732,500 00
158.2 miles from Owl Creek to Macon; total cost	16,703,184 00
211.2 miles from Rome to Macon; total cost	20,435,684 00

This closes the report of the survey and reconnaissance for the Georgia Canal project, from Rome to Macon, making the total length of canal two hundred and eleven and one-fifth miles, and the cost in round numbers twenty and a half million dollars, a sum not large when we compare it with other works of like national importance. I might refer to it as one of the grandest internal improvement projects of the day, connecting, as it does, the Northwest with the Southeast, and offering to the former cheap, constant, and safe transportation to the Atlantic for her immense and ever-increasing agricultural and other industrial products; and to the latter, the cotton-belt east of the Mississippi, cheap provisions, so very desirable to the successful cultivation of her most important staple. It might be shown how it would benefit instead of injure the railway system South, by using it as lines of distribution for the immense traffic in supplies, while it would not interfere with the travel and lighter and more valuable freights.

It could be demonstrated how the West would be greatly benefited by return cargoes of the finest pine lumber, found in great abundance in its virgin purity in passing through the pine-belt of the coast as well as the section holding these magnificent timber-lands.

The development of the mineral and manufacturing interests along the line, and the stimulus given to agriculture in general, might be considered as no small item to be secured by the construction of this new water-line. Its interior and central position might point to its great importance to the General Government in case of invasion from foreign wars. Its bearing upon commercial changes and new political and social combinations, and many other kindred topics, might enter into the discussion. But to present such is not my province, and I leave the pleasant duty to other and abler hands. To me was assigned the duty of developing the physical obstacles to be overcome, and at what probable cost; and the above is the result, based simply upon facts as they have been found to exist from as thorough an examination as time and means would permit.

Very respectfully, your obedient servant,

R. C. McCALLA,
Civil Engineer.

Major WALTER McFARLAND,
United States Engineer Corps.

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EXAMINATION OF THE COOSA RIVER, BETWEEN RAILROAD BRIDGE, NEAR WILSONVILLE, AND GREENSPORT, ALABAMA.

CHATTANOOGA, TENNESSEE, *August* 20, 1872.

MAJOR: In compliance with your instructions I have the honor to submit the following report on the survey of that portion of the Coosa River lying between the Selma, Rome, and Dalton Railroad bridge, near Wilsonville, Alabama, and Greensport, Alabama, seventy-four miles above.

The survey was begun May 27, 1872, and closed August 1, 1872. The initial point was in the center of the railroad-track, on the east bank of the river, 42 feet from the western edge of the east abutment of the Selma, Rome, and Dalton Railroad bridge.

The bridge above mentioned is a Howe truss of four spans; total length, 853 feet in clear; resting upon piers and abutments of limestone masonry. The bottom of lower chord is 133 feet above high-water mark. If the river is made navigable for steamboats, a "draw" should be put in this bridge. The river here is 850 feet wide, and about 10 feet deep. The banks are 5 feet above high water, and the country on both sides is level and under cultivation. For 7.2 miles above this we find good water until we reach the bar at Lower Tallasseehatchie Creek. This is caused by a reef of rocks that extend diagonally across the river, 300 feet above the mouth of the creek, which empties into the river from the east. The best water is along the east shore, where the reef is broken up into isolated rocks and smaller reefs. To open a channel 100 feet wide and 4½ feet deep at low water will require the removal of 1,850 cubic yards of solid rock, the estimate for which is found herewith.

One mile above Lower Tallaseehatchie Creek Talladega Creek comes in from the east immediately above Kymulga Ferry. The river here is 800 feet wide, and the banks are 10 feet above high-water-mark.

Four and a half miles above Kymulga Ferry is Lower Clear Creek Bar. It is a gravel-bar 700 feet long, and is one-quarter of a mile above Lower Clear Creek, which comes in from the east. The fall is 1.6 feet in a half mile, and it will only be necessary to excavate a channel through the bar to give good navigation. This will require the removal of 6,347 cubic yards of loose rock and gravel, the estimate for which accompanies this report.

The next obstruction to navigation is Hall's Island Shoal, 1.6 miles above Clear Creek Shoal and 14.8 miles above Coosa bridge. This is a loose rock and gravel bar extending across, at right angles to the river, from the east bank to the head of Hall's Island, and then diagonally across to the west bank. Hall's Island is 3,000 feet long and 400 feet wide. Passage-way between the island and east bank is 300 feet wide, and west bank 400 feet wide; width of river at head of island is 700 feet. The fall is 1.9 feet in one-half mile. The improvement needed here is a channel excavated through the bar, between the island and the west bank, which will require the removal of 13,676 cubic yards of loose rock and gravel, the estimates for which are herewith annexed.

Two and a quarter miles above Hall's Island brings us to Glover's Ferry. The river here is 650 feet wide and very deep. One-half mile above Glover's Ferry is the foot of Ratcliffe's Island, which is three-quarters of a mile long. At the head of this island a loose rock and gravel bar extends diagonally across the river. It will be necessary to

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excavate a channel through this bar on west side of island, removing 8,888 cubic yards of loose rock and gravel.

The next obstruction is Bell's Island Shoal. Bell's Island is 2,500 feet long, 300 feet wide at its widest part, and lies nearest the west bank, the channel on west side being only 150 feet wide. The channel on east side is 800 feet at head of island and 500 feet wide at the foot. From the foot to 300 feet above the head of this island a gravel-bar extends entirely across the river, on which there is a fall of 3 feet; and at the shallowest part the water is only 18 inches deep at the lowest stage. It will be necessary to excavate a channel at several points on the shoal, which will require the removal of 5,484 cubic yards of gravel, and in addition to that a dam, 600 feet long and 8 feet high, should be extended from west bank one-quarter of a mile below the foot of island, to deepen the water over the shoal and check the velocity of current.

The next obstruction is Turner's Mill Shoal, the foot of which is one-quarter of a mile above the mouth of Upper Clear Creek, which comes in from the east. These shoals are 2,000 feet long, and the fall is 4 feet. The width of river at foot of shoal is 800 feet, but widens out 1,000 feet above, to 1,400 feet, and at head of shoal it narrows to 800 feet again.

Nearest the east bank there is an island 2,000 feet long and 400 feet wide. The channel east of it is 200 feet wide, and west of it the channel is 900 feet wide. The improvement recommended here is to widen and deepen the channel at head of shoal, and remove detached rocks from the channel-way; also to build a dam at foot of shoal and a lock of 5 feet lift. The estimate for the same is herewith annexed.

We then have two miles of good water, which brings us to Drake's Mill Shoal. Drake's Mill is situated on the west bank, midway of the shoal, and is supplied with water by wing-dam extending along a reef diagonally up the river. A reef of rocks extend across the river opposite and at right angles to the mill, on which fish-trap dams of loose rock are built. A boat-chute for flat-boats has been blasted out through this reef, but it will have to be widened and deepened. The shoal below this reef is obstructed by numerous loose and detached rocks and smaller reefs. The best water is near the middle of the stream.

The improvement necessary here is a channel cut through the reef at head of shoal, and the removal of the loose rocks that might obstruct the channel-way, and a dam at foot of shoal high enough to make slack-water over the whole length of the shoal, with a lock of 7 feet lift. The total length of shoal is one mile, and fall 7 feet.

The next obstruction is Claunche's Shoal, which is three-quarters of a mile above Drake's Mill Shoal, and a half mile above Claunche's Ferry. This is a shoal 300 feet long, and is caused by a reef of rocks extending across at right angles to the river. The fall is 12 feet. It will be necessary to excavate a channel through this reef 100 feet wide, and deep enough to give 4½ feet of water at the lowest stage, which will require the excavation of 1,460 cubic yards of solid rock, the estimate for which accompanies this report.

Two and a quarter miles above Claunche's Shoal, a rock-reef extends across at right angles to the river. The only improvement necessary here is to cut a channel through the reef; this will require the removal of 3,587 cubic yards of rock. Perkins's Island Shoal, — miles above Coosa bridge, is the next obstruction. Perkins's Island is 2,500 feet long and 350 feet wide at its widest part. The channels on both sides of the island are 350 feet wide. At the head of the island a loose rock and gravel bar extends across the river. The fall is only six-tenths of a foot, and the

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only improvement necessary is to open a channel through the bar. Amount of work required is 2,578 cubic yards of loose rock and gravel excavation.

Collins's Ferry is two miles above Perkins's Island. River about 800 feet wide all the way, and water deep. Three-quarters of a mile above Collins's Ferry, there is another rock-reef extending across the river; 2,222 cubic yards of rock excavation will be necessary to open a channel.

Two miles farther up the river is the foot of Chockoloco Shoals, and a half mile farther Chocholoco Creek comes in from the east. Castleberry's Island, one mile and one-fourth long, and 1,000 feet wide, lies opposite mouth of creek. The passage-way between island and east bank is 150 feet wide, and between island and west bank it is 1,200 feet. The shoals begin at head of Castleberry's Island and head of Sheep Island, which is immediately below. The fall is 5 feet, and water very shallow over the whole length of shoal; some places not more than 18 inches deep. Besides excavating a channel at head of shoal, it will be necessary to build a dam, a quarter of a mile below Sheep Island, 1,000 feet long, and a lock of 7 feet lift.

One mile above the head of Castleberry's Island we find another rock-reef and shoal of gravel and loose rock, that will require 2,187 cubic yards of rock excavation and 2,187 cubic yards of gravel excavation to open a channel.

One and three-quarters of a mile above Chocholoco Shoal is Truss's Ferry, where the river is 10 to 15 feet deep, and 800 feet wide. The distance to our initial point at Coosa bridge is thirty-nine and eight-tenths miles.

Immediately above the ferry is the foot of Robertson's Island, which is 2,000 feet long and 400 feet wide. The passage-way on east side is 250 feet wide, and on west side it is 600 feet wide. The best water is on the west side. At the head of this island is Robertson's Shoal, which is a reef of rock extending across the river above the head of the island. The river here is 1,200 feet wide. The improvement needed is a channel to be opened through the reef between island and west bank. One half the excavation will be solid rock, the other half gravel.

For seven and three-fourths miles above Robertson's Shoal we find good water, with the exception of a few places, where some isolated rocks will have to be removed. The cost will not exceed $2,500. The next obstruction is a reef one-fourth of a mile below the foot of Broken Arrow Shoal. Improvement necessary is a channel excavated through the reef, which will require the removal of 943 cubic yards of solid rock.

Broken Arrow Shoal is one-fourth of a mile above the last-named obstruction. Fall, 7.1 feet; length, one and three-fourths miles.

Schouse's Island, one and three-fourths miles long, lies near the east shore, and Jones's Island, one-half mile long, lies in the middle of the stream, immediately above. A smaller island, 1,200 feet long, lies between Jones's Island and west bank, and, immediately opposite, Broken Arrow Creek comes in from the west. The best water is immediately along the west bank of Jones's and Schouse's Islands. It will be necessary to excavate a channel through the upper part of the shoal and build a dam 800 feet long, with a lock of 7 feet lift, one-fourth of a mile below the foot of Schouse's Island. Estimate of cost accompanies this report.

For one and one-half miles above Broken Arrow Shoal we find good water until we reach Box Shoal, which is a rock-reef extending across at right angles to the river, with gravel above and below the reef. The fall is 3½ feet. The proposed improvement is to remove some of the rock

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and gravel from the channel and build a dam 900 feet long below the shoal, with a lock of 5 feet lift.

For 15.6 miles above Box Shoals we find good water, with the exception of a few points, where some loose rocks will have to be taken out, the probable cost of which will be $3,000.

Miller's Reef is 67.4 miles above our initial point at Coosa bridge. The only improvement needed here is a channel opened through the reef, 100 feet wide and 4½ feet deep at low water. Two thousand four hundred cubic yards of rock excavation will cover it. Three-fourths of a mile above Miller's Reef is a gravel bar that requires a channel to be excavated through it. One thousand two hundred and seventy-six cubic yards of gravel will have to be taken out.

Midway between Miller's Reef and the shoal above, Upper Tallassee-hatchie Creek empties in from the east, just above Miller's Ferry. One and one-quarter miles above Miller's Ferry we find a reef of rocks that will require the excavation of 2,000 cubic yards of rock.

Immediately above the reef is the foot of Wood's Island, one mile long and a quarter of a mile wide. The channel east of the island is 800 feet wide, and west of it the channel is only 200 feet wide. For a half mile up the east channel we have good water until we reach the foot of Ten Island Shoal. This shoal is 7,500 feet long, and the fall is 18.1 feet. Above the head of Wood's Island there are four smaller islands, and the river spreads out to a width of 2,000 feet; the water is not more than a foot deep and very rapid. Several successive reefs of rock extend across the river, and between them the water is shallow, rapid, and filled with loose rocks, some of them above the surface. At the upper part of the shoal there are several small islands lying next to the east shore, with a passage-way next to east bank only, 150 feet wide. On the west side of these islands the channel is 1,000 feet to 1,200 feet wide. At the head of the shoal, Rock Island, a high, rocky island, 1,200 feet long and 150 feet wide, lies exactly in the middle of the stream, with a channel on each side 250 to 300 feet wide. A reef of rocks extends across from this island to both banks. It will be necessary to cut a channel through this reef on the west side of the island, which will require the excavation of 1,000 cubic yards of rock. The improvement needed for Ten Island Shoal is cutting channel through reefs, clearing loose rocks from channel-way, and building three locks and dams. The first dam, 800 feet long, at foot of the shoal, midway of Wood's Island; the second, at head of Wood's Island, and 1,800 feet in length; the third, 1,200 feet long, 2,300 feet above the second; making a total length of dams 3,800 feet. The three locks will be each 7 feet lift. The estimates of cost herewith annexed.

The next obstruction is Whistenant's Mill Shoals, eighteen miles above Ten Island Shoal. These shoals are 3,000 feet long, and the fall is 6.1 feet. The river at foot of shoal is 1,000 feet wide, and above shoal it is 700 feet wide. The upper 1,000 feet of the shoal is caused by reefs of rocks extending across the river, while the lower 2,000 feet is a gravel bar. Whistenant's mill is situated on the east bank at foot of Rock-Reefs, and is supplied with water by a race leading from the river 500 feet above. The improvement needed here is to widen the boat-chute, that has already been excavated, and build a dam 1,000 feet long at foot of shoal, with a lock of 6 feet lift, the estimates for which accompany this report. This brings us to deep water one-quarter of a mile below Greensport, Alabama, and from thence to Rome, Georgia, one hundred and eighty miles above, we have uninterrupted navigation at all seasons of the year.

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Gadsden, Alabama, is twenty-one miles above Greensport; the population is 2,500. The principal industry is the manufacture of lumber. Several steam saw-mills are in operation, and the lumber is shipped by rail to Chattanooga, and from there distributed to various points. With the opening of navigation this industry would grow to large proportions, as the country on both sides of the Coosa abounds in immense forests of long-leaf pine, and would find a market in Lower Alabama and in Mobile, from which port it would be distributed to the other Gulf ports and to the West Indies.

Rome, Georgia, is situated at the head of the Coosa, where the Etowah and Oostenaula Rivers form a junction. It is a city of 8,000 inhabitants, and is the center of a flourishing trade. The principal manufactories are a rolling-mill, a nail-factory, several founderies and machine-shops, and several flouring-mills and saw-mills. The place is improving rapidly, and, with an open river giving it a cheap outlet to the cotton-growing region of Central and Lower Alabama, it will become a great manufacturing point. From Rome, at the head of the Coosa River, to Greensport, one hundred and eighty miles below, the navigation is good at all seasons of the year. This part of the river is known as the Upper Coosa. From Greensport to Wetumpka, one hundred and thirty-seven miles below, the navigation is obstructed by numerous shoals and rapids. This part of the river is known as the Lower Coosa. Near Wetumpka the Tallapoosa and Coosa form a junction, and from that point on to the mouth of the Tombigbee, three hundred and thirty-six miles, the stream is known as the Alabama River, and is navigable at all seasons of the year. From the junction of the Tombigbee and Alabama Rivers, the stream takes the name of the Mobile River for fifty miles, to its entrance into Mobile Bay.

From this we see that the distance by river from Rome, Georgia, at the head of the Coosa River, to Mobile, Alabama, at the mouth of Mobile River, is seven hundred miles, and that navigation is good at all seasons, except on the one hundred and thirty-seven miles of river included between Greensport and Wetumpka. By the survey and estimates just completed by me, it is shown that the total cost of improvement of that portion of the river between Greensport and Coosa bridge is $470,668. From the survey and estimates made by Mr. H. C. Fillebrown, last year, it is shown that the cost of improvement of that portion of the river between Coosa bridge and Wetumpka is $1,923,020; then the total amount necessary to open navigation from Greensport to Wetumpka is $2,393,688. This gives uninterrupted navigation at all seasons of the year from Rome, Georgia, to Mobile, Alabama, a distance of seven hundred miles.

The Upper Coosa flows through one of the finest mineral regions of the world, and this improvement would give it an outlet. With the Coosa River open, the great Cababa and Coosa coal-fields would supply the cities of Central and Lower Alabama, as well as the Gulf ports and the West Indies, with large quantities of coal at low prices. I visited some of the coal-beds in the Coosa coal-fields, and found it to be a good quality of bituminous coal, and that it exists in large quantities. Iron-ore exists in even larger quantities than the coal, and in close proximity to it. There are two varieties of iron-ore, the red hematite and the brown hematite. All the elements are here for the extensive manufacture of iron. Colonel Eugene Le Hardy, an eminent civil engineer, who was formerly chief engineer of the Selma, Rome, and Dalton Railroad, that runs parallel to the Upper Coosa and crosses at Coosa Bridge,

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says, in a letter to the directors of the Cherokee, North Georgia, and North Alabama Fair Association, at Rome, Georgia:

If considered in its geological and mineralogical features, we find that few sections of country on the globe embrace, encompassed in the same area, such varieties of valuable minerals, and in such quantities, which, if developed and turned into commercial value, would suffice to make the wealth of a nation.

Besides iron and coal, he mentions the following minerals to be found in this region, viz, gold, copper, lead, plumbago, manganese, slates of superior quality, limestone, granite, sandstone, pottery, and fire-brick clay, soapstone, griststone, and marble. He says:

The marbles are of seven distinct colors, the white, the black, the variegated, the lead, the gray, the buff, and the dove-colored. The white marbles, both in texture and color, compare favorably with the finest Italian marbles.

Adjacent to the river are extensive forests of long-leaf pine, oak, and other valuable timber. At every point where improvements are necessary stone-quarries are close at hand, and easy of access.

The agricultural resources of this region are very fine on the Lower Coosa, and Alabama cotton is the principal product, while on the Upper Coosa the productions are varied; cotton is produced to a considerable extent, but the climate and soil are best adapted to grain. The opening of the river would give the people along the Upper Coosa and its tributaries, the Oostenaula River, which is navigable ninety miles, and the Etowah, which is navigable twenty miles, a fine market for their products in the cotton-growing region of Central and Lower Alabama.

To my assistants, Mr. Martin Palmer and Mr. Paul Le Hardy, and my leveller, Mr. W. A. Toms, I am indebted for intelligent and faithful assistance and co-operation in making the surveys and estimates.

I have the honor to be your most obedient servant,

JAMES C. LONG.

Major WALTER MCFARLAND,
Corps of Engineers, United States Army.

Estimate of cost and amount of work required to open for steamboat navigation that portion of the Coosa River between the Selma, Rome and Dalton Railroad bridge, near Wilsonville, Alabama, and Greensport, Alabama, seventy-four miles above.

The dams are to be of crib-work, the timbers 14 inches in diameter, filled in with heavy rock, and doubly planked with 2-inch plank. The beadings and tailings of locks to be of masonry laid in cement, and the lock-chambers to be of the same materials and construction as the dams.

Locks, cost of each 6-foot lift	$10,000 00
Dams, cost per linear foot	14 00
Hard-rock excavation, cost per cubic yard	3 00
Loose-rock excavation, cost per cubic yard	1 00
Gravel excavation, per cubic yard	1 00
Lower Tallassahatche Creek Bar:	
Rock excavation, 1,850 cubic yards, at $3	$5,550 00
Lower Clear Creek Bar:	
Loose-rock and gravel excavation, 6,347 cubic yards, at $1	6,347 00
Hall's Island Shoal:	
Loose-rock and gravel excavation, 13,676 cubic yards, at $1	13,676 00
Ratcliffe's Island Shoal:	
Loose-rock and gravel excavation, 8,888 cubic yards, at $1	8,888 00

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Bell's Island Shoal:		
Gravel excavation, 5,484 cubic yards, at $1	$5,484 00	
Dam, 600 feet long, at $14	8,400 00	
		$13,884 00
Turner's Mill Shoal:		
Rock excavation, 2,736 cubic yards, at $3	8,208 00	
Dam, 800 linear feet, at $14	11,200 00	
Lock, 5-foot lift	9,000 00	
		28,408 00
Drake's Mill Shoal:		
Rock excavation, 2,086 cubic yards, at $3	6,258 00	
Dam, 1,000 linear feet, at $14	14,000 00	
Lock, 7-foot lift, at $14	11,000 00	
		31,258 00
Claunche's Shoal:		
Solid-rock excavation, 1,460 cubic yards, at $3		4,380 00
Shoal, two and a quarter miles above Claunche's Shoal:		
Rock excavations, 3,587 cubic yards, at $3		10,761 00
Perkins Island Shoal:		
Loose-rock and gravel excavation, 2,578 cubic yards, at $1		2,578 00
Shoal, three-quarters of a mile above Collins Ferry:		
Rock excavation, 2,222 cubic yards, at $3		6,666 00
Chockoloco Shoal:		
Rock excavation, 1,500 cubic yards, at $3	$4,500 00	
Gravel excavation, 1,500 cubic yards, at $1	1,500 00	
Dam, 1,000 linear feet, at $14	14,000 00	
Lock, 7-foot lift	11,000 00	
		31,000 00
Shoal, one mile above Chockoloco:		
Rock excavation, 2,187 cubic yards, at $3	6,561 00	
Gravel excavation, 2,187 cubic yards, at $1	2,187 00	
		8,748 00
Robertson's Shoal:		
Rock excavation, 1,250 cubic yards, at $3	3,750 00	
Gravel excavation, 1,250 cubic yards, at $1	1,250 00	
		5,000 00
From Robertson's Shoal to foot of Broken Arrow Shoal some rocks to be removed; estimated cost		2,500 00
Reef, one-quarter of a mile below Broken Arrow Shoal:		
Rock excavation, 943 cubic yards, at $3		2,829 00
Broken Arrow Shoal:		
Rock excavation, 161 cubic yards, at $3	$483 00	
Gravel excavation, 322 cubic yards, at $1	322 00	
Dam, 900 linear feet, at $14	12,600 00	
Lock, 5-foot lift	9,000 00	
		22,405 00
Loose rock between Box Shoal and Miller's Reef		3,000 00
Miller's Reef:		
Rock excavation, 2,400 cubic yards, at $3		7,200 00
Three-quarters of a mile above Miller's Reef:		
Loose-rock and gravel excavation, 1,276 cubic yards, at $1		1,276 00
Reef one and a quarter miles above Miller's Ferry:		
Rock excavation, 2,000 cubic yards, at $3		6,000 00

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Ten Island Shoal:		
Rock excavation, 7,506 cubic yards, at $3	$22,518 00	
Dams, 3,800 linear feet, at $14	53,200 00	
Locks, three, each 7-foot lift	33,000 00	
		$108,718 00
Whistenant's Mill Shoal:		
Rock excavation, 3,000 cubic yards, at $3	9,000 00	
Dam, 1,000 linear feet, at $14	14,000 00	
Lock, 6-foot lift	10,000,00	
		33,000 00
		392,224 00
Add 20 per cent. for contingencies		78,444 00
Total estimated cost		470,668 00

M 10.

EXAMINATION OF THE ETOWAH RIVER FROM RAILROAD-BRIDGE, NEAR CARTERSVILLE, TO ROME, GEORGIA.

CHATTANOOGA, TENNESSEE, *August* 24, 1872.

MAJOR: In compliance with your instructions I have the honor to submit the following report of an examination of the Etowah River, from the bridge of the Western and Atlantic Railroad, near Cartersville, Georgia, to its junction with the Oostenaula and Coosa Rivers at Rome, Georgia.

The bridge of the Western and Atlantic Railroad is a Howe-truss wooden bridge, with five spans of about 70 feet each. The bottom of lower chord is about 30 feet above high-water mark. River at this point 250 feet wide. A shoal begins at the railroad-bridge and extends down the river 1,500 feet. Eight hundred feet below the bridge is an old mill with a dam built of loose rock, extending entirely across the stream. It will be necessary to remove a portion of this dam, say 100 by 8 by 10 feet loose rock, and build a dam 250 feet long at foot of shoal, and a lock of 4 feet lift. The fall is only two feet on the shoal, but it will cost less to build a dam and lock than to excavate a channel the whole length of the shoal; estimate for which is annexed to this report.

We find the water from 6 to 12 feet deep for a half mile farther down, which brings us to Puckett's Ferry, and 500 feet below Puckett's Ferry a loose rock and gravel bar extends across the river. The fall here is 18 feet. The improvement needed is a channel excavated through the bar 400 feet long, 80 feet wide, and 2 feet deep. One and a quarter miles below the Western and Atlantic Railroad bridge we come to L. Tumlin's mill and ferry, where it will be necessary to build a dam 9 feet high and 250 feet long, with a lock of 5 feet lift.

One-quarter of a mile below Tumlin's mill there is a gravel-bar where a channel will have to be cut 600 feet long, 80 feet wide, and 1 foot deep.

One-half mile below Tumlin's mill is a loose rock and gravel bar, that will require a channel to be opened through it 200 feet long, 80 feet wide, and 2½ feet deep.

One mile below Tumlin's mill is another gravel-bar, through which a channel will have to be opened 100 by 80 by 2½ feet, loose rock and gravel.

One-half mile above Douthard's Ferry there is a gravel-bar, where the only improvement needed is a channel to be cut through the bar, 200 by 80 by 2 feet. Bar at Douthard's Ferry, three miles below Tumlin's

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mill, is composed of loose rock and gravel. A channel 300 by 2½ by 80 feet will give sufficient water-way. River at this point is about 225 feet wide.

About three-quarters of a mile below Douthard's Ferry the river widens out to 350 feet wide, forming a shoal 3,500 feet in length, on which there is a total fall of 3½ feet. The water is only 2 feet deep.

The improvement required here is a dam 250 feet long, and a lock of 5 feet lift; also the removal of 50 cubic yards solid rock, and 700 cubic yards loose rock. There is a truss-bridge here, 350 feet long, which will have to be remodeled. The banks of the river are generally 12 feet high.

At the foot of the last-mentioned shoal the river contracts to a width of 225 feet, and occasionally widens out to 250 feet, until we reach a shoal about 600 feet above Roland's Ferry. At the upper end of this shoal a reef of rocks contracts the channel-way to 50 feet in width. Below the reef a gravel-bar extends across the stream, through which it will be necessary to widen the channel through the rock-reef at the head of shoal.

On both sides of the river there is a beautiful and fertile country; the soil is dark red, very rich, and the land is under a high state of cultivation.

At Roland's Ferry the banks are 20 feet high. The high-water mark is 9.8 feet above the low stage of water. Petit's Creek makes in from the right bank, just opposite here. The river is 200 feet wide.

One-half mile below Roland's Ferry we come to the bridge of the Cartersville and Van Wert Railroad; it is a Howe truss, and is 192 feet long in the clear, and reaches across the river in one span; bottom of lower chord is 21.4 feet above low water, or 11.6 feet above the highest stage of water. Depth of water in the channel, 6 feet. It will be necessary to put a draw in this bridge.

One-third of a mile below the above bridge is a rock-reef, through which it will be necessary to cut a channel 50 by 80 by 2 feet.

Three-quarters of a mile below the railroad-bridge is a fish-trap dam to be taken out; 185 cubic yards of loose rock will cover the amount of material to be excavated.

Two miles below the bridge of the Cartersville and Van Wert Railroad is a gravel-bar and fish-trap dam, known as Rowland's Shoal. Improvement needed here is a channel 300 feet long, 3 feet deep, and 80 feet wide.

One-half mile below Rowland's Shoal is a gravel-bar 300 feet long, with only 3 feet depth of water and considerable current. It will be necessary here to build a wing-dam of riprap, below the shoal, 7 feet high and 300 feet long, to back the water up over the bar, and make it deeper.

We have good water for the next five miles, where we find a solid-rock reef extending across the river, about half a mile above Stiles's house. Excavation in solid rock, necessary to make a good channel, 100 by 80 by 2 feet.

For the next one and a half miles we have from 4 to 10 feet of water, until we reach a reef of rocks extending across at right angles to the course of the river. Below this reef a gravel-bar extends 400 feet farther down the river. It will be necessary to cut a channel through this shoal 450 feet long, 80 feet wide, and 3 feet deep. One-eighth of the material will be solid rock, and the rest gravel and loose rock. The width of the river here is 250 feet. The banks are 20 feet high, and there is a high rolling country extending back from the river on both sides.

Three-fourths of a mile farther down the river there is a rock-reef

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extending across the river, on which there are only 2 feet of water at a low stage.

It will be necessary to cut a channel through this reef 200 feet long, 80 feet wide, and 2 feet deep. The amount of excavation will be 1,185 cubic yards of solid rock. There is not much fall over the reef. The country is flat on the right, and hilly on the left of the river.

One-third of a mile farther down there is another reef, which is one-quarter of a mile above Thomas Tumlin's ferry. There are 6 feet of water above the reef, 18 inches on the reef, and 6 feet below, and not much current. Excavation necessary to open a channel, 100 by 80 by 3 feet in solid rock.

At Thomas Tumlin's ferry the river is 230 feet wide, and there are 8 feet water in the channel. Banks are about 20 feet high, with a level country on both sides of the river.

The distance to the railroad-bridge at Cartersville is about 15 miles. Enharly Creek makes in on the left bank, one-eighth mile below the ferry. One-half mile below Thomas Tumlin's ferry is a fish-trap dam and a shoal 1,500 feet in length. The river here is 350 feet wide, and not more than 18 inches deep. The fall is 2.6 feet the whole length of the shoal. Banks are 18 feet high, and increasing in height from the river. At foot of shoal the river contracts to 200 feet wide, and the water is 8 feet deep. The improvement needed here is a dam to make slack-water over the shoal, with a lock of 5 feet lift. Length of dam, 250 feet.

At Milam's Ferry the river is 350 feet wide, and water 8 feet deep in the channel. One-quarter of a mile below Milam's Ferry is a loose rock and gravel bar. The fall is 0.7 foot; excavation necessary to make a channel is 400 by 80 by 3 feet, gravel and loose rock.

Calhoun's Island is situated one mile below Milam's Ferry. There is a gravel-bar extending from the head of this island to the right bank. The improvement needed here is a channel to be excavated through the bar 500 feet long, 80 feet wide, and 1½ feet deep, and in addition thereto a dam to be built from the head of the island to the left bank, to deflect the water into the right-hand chute. This dam to be riprap, 200 feet long and 6 feet high.

Three hundred feet below the foot of Calhoun's Island there is a rock-reef extending across the river that will require a channel to be excavated in rock 150 by 80 by 2 feet.

Two miles below Milam's Ferry we come to Calhoun's and Sayre's Ferry, which is about ten miles from Cartersville by the country road, and four miles from Kingston. The distance to Cartersville bridge is about eighteen miles by the river. One-quarter of a mile below Calhoun's Ferry there is a reef of rocks extending diagonally across the river. The water above the reef is 6 feet deep, on the reef 2 feet; below the reef it is 5 feet deep; the fall is 6 inches. The improvement necessary is a channel cut through the reef 150 by 80 by 2 feet, all solid rock.

For the next three-quarters of a mile we have from 5 to 8 feet of water, which brings us to a shoal three-quarters of a mile below Calhoun's Ferry. Here a reef of ragged, broken rocks extends across the river. About 400 cubic yards of rock blasted out will give a channel 80 feet wide and 4 feet deep. Rocky bluffs extend down to the river on the left bank, but on the right bank the country is level.

At Mark Harden's ferry and the shoal immediately below, the river widens out from 300 to 700 feet wide, with reefs of rocks extending across the river at intervals for 1,200 feet, with a fall in that distance of 2.47 feet.

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There are about 1,000 feet of slackwater between this shoal and another below; but on account of the great width of the river the water is only 3 feet deep. The river then begins to fall rapidly, and the water becomes only 18 inches deep. The fall in 2,000 feet is 6.46 feet. This will make the total fall of the two shoals 8.93 feet. The improvement necessary here is a dam 500 feet long, and a lock of 10 feet lift. The banks are very high, and there will be no difficulty in giving the required lift to the lock, as there will be no danger of overflowing the adjacent lands. Frick's Ford Island is situated at the foot of the above shoals. One-quarter of a mile below Frick's Ford Island there is a rock-reef extending across the river. Excavation necessary to open a channel through the reef, 100 by 80 by 3 feet, all rock. One-half mile below, another reef; excavation 150 by 80 by 2 feet, all rock.

About one-quarter of a mile above Reynolds's Ford there is a gravel-bar and fish-trap dam. Shoal 400 feet long, with 2 feet depth of water. It will be necessary to open a channel through the bar 400 feet long, 80 feet wide, and 2 feet deep, all gravel.

At Reynolds's Ford there is a gravel-bar extending entirely across the river, and 400 feet long. Water 3½ feet above the bar, 2½ feet on the bar, and 7 feet below the bar.

The best water is along the right bank. The improvement needed here is a riprap wing-dam 300 feet long and 6 feet high, to back the water up on the shoal and make it deeper.

There is a rock-reef and gravel-bar extending across the river one-half mile below Reynolds's Ford. There are 7 feet of water above the bar, 2 feet on the bar, and 8 feet below the bar. Excavation necessary to open a channel, 200 by 80 by 2 feet, one-half gravel and the other half solid rock.

One mile below Reynolds's Ford there is a shoal on which there are only 18 inches of water. Length of shoal is 1,300 feet, and the fall is 3 feet. Width of river at foot of shoal is 350 feet. Improvement needed here is a dam below the shoal 350 feet long and a lock of 5 feet lift.

Two-Rod Creek makes in at this shoal from the right bank. Conoseen Creek comes in from the right bank one-half mile below.

One-half mile below the mouth of Conoseen Creek we come to Worley's bridge, which is a Howe truss, about 300 feet long. Bottom of lower chord is 13 feet above high-water mark. High water is 12 feet above low water.

For one mile below Worley's bridge we have good water from 4 to 10 feet deep. This brings us to a shoal and fish-trap dam. A channel will have to be opened through this shoal 300 by 2 by 80 feet. There is a rock-reef one and one-half miles below Worley's bridge that will have to have a channel excavated 50 by 80 by 3 feet, solid rock. Two miles below Worley's bridge there is a shoal 3,000 feet long, on which there is a fall of 6 feet. The banks on both sides are 20 feet high, and on the lower half a hill slopes down to the river on the left. The improvement recommended here is a dam across the river below the shoal, 300 feet long, and a lock of 6 feet lift. This will make slackwater over the whole length of the shoal. At the upper end it will be necessary to cut a channel through a rock-reef 75 by 80 by 2 feet in solid rock. The above shoas are known as Muchison's Shoals.

One-half mile below Muchison's Shoals we come to Mayhew's Ferry. The river here is 300 feet wide, banks 20 feet high; hilly country on both sides of the river.

For one and one-half miles below Mayhew's Ferry we have good water

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from 4 to 12 feet deep, with the exception of a small gravel-bar at the ferry. Excavation necessary to open a channel, 150 by 80 by 2 feet.

One and a half miles below Mayhew's Ferry there is a small island near the left shore, and between this and right shore there is a small gravel-bar 150 by 80 by 2 feet; gravel excavation needed.

Two miles below Mayhew's Ferry we come to Eaves' Station on the Rome Railroad. The railroad has been running along on the bank of the river ever since leaving Worley's bridge, four and one-half miles above.

There is a gravel-bar 800 feet below Eaves' Station, where it is necessary to make an excavation 300 by 80 by 2 feet, in gravel.

Skinner's Shoal is one-half mile below Eaves' Station; it is 1,200 feet long with a fall of 2 feet. Improvement recommended here is to excavate a channel-way two-thirds the length of the shoal, and in addition to build a riprap wing-dam 350 feet long and 6 feet high to check the current and back the water sufficiently to deepen the channel.

There is a rock-reef and gravel-bar situated one-fourth mile above Bass's Ferry. There is very little fall, and all that is necessary to open the channel is to make an excavation 200 by 80 by 2 feet, one half rock, the other half gravel. For one and a half miles below Bass's Ferry there is good water; banks 18 to 22 feet high; river 300 feet wide on an average, sometimes widening out to 350 feet, and again contracting to 250 feet. Occasionally bluffs and hills extend down to the river, and then the country opens out again, first on one side of the river and then on the other side.

Two miles below Bass's Ferry there is a shoal 2,500 feet long, on which there are but 2 feet of water. The fall is three and one-half feet. The improvement needed here is a dam to be built below the shoal, and a lock of 5 feet lift. Six hundred feet below, some loose rocks obstruct the channel; 600 cubic yards will cover the amount to be removed.

Three miles below Bass's Ferry we come to a shoal 500 feet long. There is an old mill-dam of loose rock extending nearly across the river, about 50 feet of which will have to be removed; also a channel will have to be excavated along the left shore, 500 by 80 by 2 feet. All the excavation will be gravel and loose rock. In addition to the above a wing-dam of riprap, 300 feet long and 6 feet high, should be built below the shoal to deepen the water and check the current.

Three and one-fourth miles below Bass's Ferry there is a rock-reef making across the river immediately above Ayer's Ferry. Excavation necessary here is 200 by 80 by 2½ feet, one half rock, the other half gravel. This brings us to Ayer's Ferry, three and one-fourth miles below Bass's Ferry, and seven miles above Rome. River 400 feet wide; banks about 16 feet high.

Two hundred yards below Ayer's Ferry there is a rock-reef extending across the river. There are 7 feet of water above the reef, 2 feet on the reef, and 8 feet below. Improvement necessary here is a channel to be cut through the rock, 200 by 80 by 2½ feet, half of which will be rock and the other half gravel.

One mile below Ayer's Ferry we come to Freeman's Ferry, and a half mile below there is a shoal and fish-trap dam. We have 2½ to 3 feet of water for another half mile, then another fish-trap dam with a fall of 1.2 feet. A dam 350 feet long should be located here, and a lock of 6 feet lift; this would deepen the water over the mile and a half of shoal water above. The above shoal is known as Mathew's Shoal.

There is another gravel-bar and fish-trap dam one-half mile below Mathew's Shoal. Excavation necessary here is 200 by 80 by 3 feet, all gravel and loose rock.

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One mile below Mathew's Shoal there is another reef and gravel-bar. Excavation 100 by 80 by 2½ feet, one half rock, the other half gravel.

Two miles below Mathew's Shoal there is a rock-reef and gravel-bar on which there are but 2 feet of water, and the whole two miles are shoaly, ranging from 2½ to 4½ feet of water. One-half mile below there is another gravel-bar and fish-trap dam. The bar is 400 feet long, and the fall is two feet. A dam 400 feet long located here, with a lock of 6 feet lift, will give sufficient depth of water all the way to Mathew's Shoal, two and a half miles above Rome, two and a half miles distant.

About a mile above the mouth of the river two channels are formed by an island. The best water is in the left-hand channel. It will be necessary to build a wing-dam of riprap, 200 feet long and 6 feet high, from the head of the island to the right-hand bank, to deflect the water into and deepen the left channel.

Opposite to the city of Rome, and a quarter of a mile above the mouth of the Etowah River, there are two bridges, one a railroad Howe truss, and the other a street-bridge of the Howe-truss pattern, neither of which has "draws." Steamboats can pass under them by lowering their smoke-stacks, except during freshets.

Estimates for above-described improvements on the Etowah River, from the Western and Atlantic Railroad bridge, near Cartersville, Georgia, to Rome, Georgia, a distance of about fifty miles, are herewith annexed.

I have the honor to be your most obedient servant,

JAS. G. LONG,
Civil Engineer.

Major WALTER McFARLAND,
Corps of Engineers, United States Army.

Estimate for improvements of the Etowah River, from the bridge of the Western and Atlantic Railroad near Cartersville, Georgia, to Rome, Georgia, some fifty miles below, to give a depth of 3½ feet of water at extreme low stage.

The dams are to be crib-work, the timbers of which are 14 inches in diameter, filled in with heavy rock, and doubly planked with 2-inch plank. The headings and tailings of locks to be of masonry laid in cement, and the lock-chambers to be of crib-work of the same construction as the dams.

Shoal at McClatchen's mill:		
Loose-rock excavation, 300 cubic yards, at $1	$300 00	
Dam, 250 linear feet, at $11.50	2,875 00	
Lock, 4 feet lift	8,000 00	
		$11,175 00
Shoal 500 feet below Puckett's Ferry:		
2,370 cubic yards loose rock and gravel, at $1		2,370 00
Shoal at Tumlin's mill:		
Dam 250 feet long, at $14	3,500 00	
Lock, 5 feet lift	9,000 00	
		12,500 00
Bar one-quarter of a mile below Tumlin's mill:		
Gravel excavation, 1,777 cubic yards, at $1		1,777 00
Bar one-half mile below Tumlin's mill:		
Gravel excavation, 1,481 cubic yards, at $1		1,481 00
Bar one mile below Tumlin's mill:		
Gravel excavation, 740 cubic yards, at $1		740 00
Bar one-half mile below Douthard's Ferry:		
Gravel excavation, 1,185 cubic yards, at $1		1,185 00

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Bar at Douthard's Ferry:		
Gravel excavation, 2,222 cubic yards, at $1		$2,222 00
Bar three-quarters of a mile below Douthard's Ferry:		
50 cubic yards solid rock, at $3	$150 00	
700 cubic yards loose rock, at $1	700 00	
Dam, 250 linear feet, at $14	3,500 00	
Lock, 5 feet lift	9,000 00	
		13,350 00
Bar 600 feet above Rowland's Ferry:		
Solid-rock excavation, 200 cubic yards, at $3	600 00	
Gravel excavation, 518 cubic yards, at $1	518 00	
		1,118 00
Reef three-quarters of a mile below Rowland's Ferry:		
Rock excavation, 300 cubic yards, at $3		900 00
Fish-trap dam, one-quarter of a mile below Rowland's Ferry:		
185 cubic yards loose-rock excavation, at $1		185 00
Rowland's Shoal:		
2,666 cubic yards loose rock, at $1		2,666 00
One-half mile below Rowland's Shoal:		
Riprap dam, 1,000 cubic yards, at $1		1,000 00
Reef five and a half miles below Rowland's Shoal:		
Solid-rock excavation, 591 cubic yards, at $3		1,773 00
Reef one and a half miles below:		
500 cubic yards rock excavation, at $3	$1,500 00	
3,500 cubic yards gravel excavation, at $1	3,500 00	
		5,000 00
Reef seven and a quarter miles below Rowland's Ferry:		
Solid-rock excavation, 1,185 cubic yards, at $3		3,555 00
Reef one-quarter of a mile above Thomas Tumlin's ferry:		
Solid-rock excavation, 888 cubic yards, at $3		2,664 00
Shoal one-half mile below Thomas Tumlin's ferry:		
Dam, 250 linear feet, at $14	$3,500 00	
One lock, 5 feet lift	9,000 00	
		12,500 00
Gravel-bar one-quarter of a mile below Milam's Ferry:		
Loose-rock and gravel excavation, 3,555 cubic yards, at $1		3,555 00
Calhoun's Island Bar:		
1,007 cubic yards wing-dam, at $1.50	$1,510 50	
2,222 cubic yards gravel excavation, at $1	2,222 00	
		3,732 50
Reef 300 feet below Calhoun's Island:		
Solid-rock excavation, 888 cubic yards, at $3		2,664 00
Reef one-quarter of a mile below Calhoun's Ferry:		
Solid-rock excavation, 883 cubic yards, at $3		2,664 00
Reef three-quarters of a mile below Calhoun's Ferry:		
Solid-rock excavation, 400 cubic yards, at $3		1,200 00
Harden's Shoal:		
Dam, 500 linear feet, at $14	$7,000 00	
1 lock, 10 feet lift	14,000 00	
		21,000 00
Reef one-quarter of a mile below Frick's Ford Island:		
Solid-rock excavation, 888 cubic yards, at $3		2,664 00
Reef three-quarters of a mile below Frick's Ford Island:		
Solid-rock excavation, 888 cubic yards, at $3		2,664 00

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Gravel-bar one-quarter of a mile above Reynolds's Ford:		
Gravel and loose-rock excavation, 2,370 cubic yards, at $1		$2,370 00
Bar at Reynolds's Ford:		
1,133 cubic yards of wing-dam, at $1.50		1,699 50
Bar one-half mile below Reynolds's Ford:		
Solid-rock excavation, 592 cubic yards, at $3	$1,776 00	
Gravel excavation, 592 cubic yards, at $1	592 00	
		2,368 00
Shoal one mile below Reynolds's Ford:		
Dam, 350 linear feet, at $14	4,900 00	
1 lock, 5 feet lift	9,000 00	
		13,900 00
Gravel-bar one mile below Worley's bridge:		
Gravel excavation, 1,777 cubic yards, at $1		1,777 00
Reef one and a half miles below Worley's bridge:		
Solid-rock excavation, 444 cubic yards, at $3		1,332 00
Muchison's Shoals:		
Solid-rock excavation, 442 cubic yards, at $3	$1,326 00	
Dam, 300 linear feet, at $14	4,200 00	
Lock, 6 feet lift	10,000 00	
		15,526 00
Bar at Mayhew's Ferry:		
Gravel excavation, 1,066 cubic yards, at $1		1,066 00
Gravel-bar one and a half miles below Mayhew's Ferry:		
Gravel excavation, 888 cubic yards, at $1		888 00
Bar 800 feet below Eaves Station:		
Gravel excavation, 1,776 cubic yards, at $1		1,776 00
Skinner's Shoal:		
Gravel excavation, 4,740 cubic yards, at $1	$4,740 00	
1,244 cubic yards wing-dam, at $1.50	1,866 00	
		6,606 00
Reef one-quarter of a mile below Bass's Ferry:		
Solid-rock excavation, 590 cubic yards, at $3	1,770 00	
Gravel excavation, 590 cubic yards, at $1	590 00	
		2,360 00
Shoal two miles below Bass's Ferry:		
600 cubic yards solid-rock excavation, at $3	1,800 00	
Dam, 300 linear feet, at $14	4,200 00	
1 lock, 5 feet lift	9,000 00	
		15,000 00
Shoal three miles below Bass's Ferry:		
Gravel excavation, 2,950 cubic yards, at $1	2,950 00	
Wing-dam, 1,140 cubic yards, at $1.50	1,710 00	
		4,660 00
Reef at Ayer's Ferry:		
Gravel excavation, 730 cubic yards, at $1	730 00	
Solid-rock excavation, 730 cubic yards, at $3	2,190 00	
		2,920 00
Bar 200 yards below Ayer's Ferry:		
Solid-rock excavation, 730 cubic yards, at $3	2,190 00	
Gravel excavation, 730 cubic yards, at $1	730 00	
		2,920 00
Shoal three-quarters of a mile below Freeman's Ferry:		
Dam, 350 linear feet, at $14	4,900 00	
1 lock, 6 feet lift	10,000 00	
		14,900 00

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Bar one and a quarter miles below Freeman's Ferry:		
Gravel excavation, 1,760 cubic yards, at $1		$1,760 00
Reef one and three-quarter miles below Freeman's Ferry:		
Solid-rock excavation, 365 cubic yards, at $3	$1,095 00	
Gravel excavation, 365 cubic yards, at $1	365 00	
		1,460 00
Reef and shoal two and three-quarter miles below Freeman's Ferry:		
Dam, 300 linear feet, at $14	$4,200 00	
1 lock, 6 feet lift	10,000 00	
		14,200 00
Bar at Rome:		
Wing-dam, 760 cubic yards, at $1.50		1,140 00
		228,932 00
Add 20 per cent. for contingencies		45,786 00
Total estimated cost		274,718 00

APPENDIX N.

ANNUAL REPORT OF CAPTAIN C. W. HOWELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDED JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
New Orleans, Louisiana, July 20, 1872.

GENERAL: I have the honor to submit the following report of progress made in all works of river and harbor improvement under my charge, for the fiscal year ended June 30, 1872.

I.—IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER AT SOUTHWEST PASS, LOUISIANA.

MAINTENANCE OF CHANNEL.

On the 1st of July, 1871, I reported a channel across the bar at Southwest Pass 18½ feet in depth at mean low tide, and having for that depth a width at its narrowest point of 250 feet.

By occasional work this depth and width were maintained until the 22d of July. At this date the stage of the river, being 11 feet below high water of 1862, appeared to favor suspension of work for the summer. The dredge-boat was therefore ordered to this city, and preparations begun for making general repairs.

It was not found necessary to recommence work at Southwest Pass until November 15, 1871, at which date the channel having shoaled to 17 feet, and it being considered desirable to prepare as good a channel as possible before any marked rise in the river occurred, work was resumed.

On November 20 it was found that the channel had been deepened to 19 feet and had a width of 300 feet. Although no further work was done, the channel remained unchanged during the remainder of the month.

No work was necessary during the month of December, the channel remaining unchanged.

On the 19th of January, 1872, the channel at one point was found filled in to 18 feet. A few hours' work on the 9th and 10th cleared this

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and gave a channel 19½ feet deep. On the 23d but 18½ feet were reported. This on the 26th had again been made 19½ feet.

During the time, however, from the 20th of November to this date, the sides of the channel had been gradually silting up, until at the narrowest point there was only available between the 18-foot curves a width of 195 feet.

During February and March work was continued at intervals as required to maintain a 19-foot channel. In the latter part of March the spring rise in the river began to make itself felt on the bar, and more active work became necessary about the middle of April, the rise having attained its medium stage. For a few days after the 15th of the month the depth of channel varied under the work of the dredge from 17 to 17½ feet. On the 26th this had been increased to 18 feet. On and after the 27th, for the rest of the month, 19 feet were available. During May the depth was maintained at 18 to 19 feet, with the exception of a few days, when it varied from 17 to 18 feet. On the 27th the depth was 19 feet; on the 31st, 18½ feet. Work was suspended from May 27 to June 10 for repairs to the dredge. During this time an attempt, entirely similar to others heretofore reported, was made to blockade the channel. The early return of the dredge to her work, and the regulations I caused to be enforced, frustrated the scheme, but not until much damage had been done in the way of shoaling and contracting the channel and in obstructing the working of the dredge. In this connection attention is again called to the necessity for establishing and enforcing penalties to prevent such vicious action.

Until the 21st of June the depth of channel ranged from 17 to 18 feet, but the channel was both narrow and crooked, caused by grounding of vessels on its sides.

After the 21st the depth was kept at from 18 to 18½ feet, and the channel straightened, besides being made considerably wider.

At the close of the year a good 18-foot channel was available.

For further particulars see tabular statement herewith.

THE DREDGE-BOAT ESSAYONS.

When laid up for repairs in July, 1871, the dredge had completed three years' work without undergoing general repairs.

The effects of a climate not favorable to the preservation of wooden hulls were shown in the serious decay of many of the vessel's timbers, particularly amidships, and in the condition of decks, deck-beams, and cabins; besides, the forward part of the vessel was found badly racked from the action of the excavating-propeller.

Repairs indicated were made with a view to putting the hull in condition for one season's work, leaving the thorough repair of the hull for the present year.

The steam-machinery it was necessary to put in complete repair. An entire new set of 1,200 tubes was put in the boilers. The condensers required extensive repairs. The old circulating-pumps having worn out were replaced by new ones. A new bilge-pump was put in, and new thrust-bearing, couplings, casings, and sleeve-lining provided for the propeller-shafts. This constituted the bulk of repairs to steam-machinery. Many minor repairs were made which it would take too long to detail.

The dredging-machinery proper needed but slight repair. After these were completed, and the dredge resumed work on the bar, no further repair was called for until during May, 1872. During this month

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the excavating-propeller was twice broken and repaired, having previously run nearly one year without breakage.

During the present year extensive repairs to the hull are contemplated, also the usual repairs to propeller-shaft, casing, and bearings.

NEW DREDGE-BOAT.

This was completed during the year, but too late to be placed at work on the bar until after the 30th of June. She has since been well tested at Southwest Pass, and works in every way to my satisfaction. The vessel has been named the General M. D. McAlester, in honor of the late Brevet Brigadier-General M. D. McAlester, major of engineers, who inaugurated the plan (just completed by the construction of this vessel) on which our work at the mouth of the Mississippi has been conducted.

Detailed drawings of the McAlester will be forwarded the Department as soon as tracings for file in this office are completed. With them will be sent photographs and a revised copy of specifications.

SURVEYS.

Surveys at the mouth of the river were continued during the year with as much regularity and system as possible. My monthly reports have already informed you of the difficulties attending this part of the work, the principal being failure to secure the services of a suitable assistant in charge. The last one employed is doing well, is competent, faithful, and, what is of great importance, takes more than ordinary interest in making the investigations directed.

Financial statement.

Available June 30, 1871		$307,278 80
Appropriation of 1872		155,000 00
Total available since June 30, 1871		462,278 80
Expended during last fiscal year		287,003 06
Balance available June 30, 1872		175,275 74
Outstanding indebtedness:		
Due on new dredge-boat	$49,489 34	
To be returned to appropriation of 1869	5,500 00	
Miscellaneous	4,469 76	
		59,459 10
Available for work this year		115,816 64

This amount falls short of my estimate for the year by nearly $10,000.

In expectation of having the full amount of my estimate for next year appropriated, I shall not ask for an additional appropriation to make good the deficit.

It is recommended that there be appropriated for the year ending June 30, 1874, the sum of $125,000.

The following statement of the commerce of this port for the past year has been received from the office of the collector of customs, viz:

Number of entrances—steam-vessels	616
Tonnage	639,943.88
Number of clearances—steam-vessels	704
Tonnage	739,850.21
Number of entrances—sail-vessels	945
Tonnage	436,650.77
Number of clearances—sail-vessels	1,000
Tonnage	457,996.23

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Total value of imports:	
Specie, free and dutiable	$18,542,188
Total value of exports:	
Domestic, to foreign countries	$89,501,149 00
Foreign, to foreign countries	1,301,700 00
Total of exports	90,802,849 00
Amount of revenue collected on imports	$5,184,053 93

A comparison of this statement with the commercial statement submitted in my report for the preceding year, gives gratifying evidence of the great benefit commerce has derived from the work of improvement at Southwest Pass.

It will be observed that the total value of imports and exports is about the same for the two years, notwithstanding the reduced value of the most important articles of export for the past year, while the number of vessels engaged in the trade has been greatly reduced. This indicates that vessels have been loaded to their full capacity and draught, instead of being, as in previous years, but partially loaded. The money-value of this privilege to ship-owners, in increase of profits, or to shippers, in reduction of freight, cannot be estimated.

The past year's work had the further effect of inspiring business men with confidence in its successful continuance, and in consequence there is predicted for the present year a large increase in the business of this port.

Several new steamers will be added this fall to the old lines now running here, and two new European lines will have twelve fine steamships ready to enter the trade at the same time. These latter have been attracted by the growing importance of this port as a point for the export of grain in bulk, an importance given it by the cheapness and facility with which grain in bulk can be delivered here in model barges from Saint Louis and other points on the Mississippi and its tributaries, and by the possibility of taking large cargoes over the bar at Southwest Pass in its present improved condition.

PROJECT FOR THE YEAR ENDING JUNE 30, 1873.

It is proposed to discontinue the work early in August, the stage of the river being favorable, and to only recommence work on the bar when the channel shall have shoaled to 18 feet. It is thought that this will not occur until the commencement of the fall rise in the river.

During the summer repairs to the Essayons will be made.

SURVEYS WILL BE CONTINUED.

The work is not susceptible of permanent completion. It is located in the collection-district of New Orleans, and at Southwest Pass, near the light-house at the entrance to that pass.

II.—IMPROVEMENT OF THE INNER BAR AT THE ENTRANCE TO THE HARBOR OF GALVESTON, TEXAS.

With the appropriation available during the past year, a dredge-boat, two dump-scows, and a steam tug-boat were purchased and held in readiness for work on the bar when needed. That these were not needed or worked during the year is due to the good effect produced by

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the jettee constructed by the city of Galveston, as heretofore reported. This jettee caused the channel across the inner bar to cut out and remain with a depth equal to that available over the outer bar. Under the circumstances, dredging to further deepen or to widen the channel would have been an expense from which no benefit could have been derived. I could, therefore, only hold the dredge in condition to work the channel in case the jettee should be destroyed by storms, or from other causes fail to maintain a good channel.

Under authority from the Secretary of War, of which I was notified by letter from the Chief of Engineers, dated May 25, 1872, I have allowed Messrs. J. S. Sellers & Co., of Galveston, the use of the dredge for improving their wharf-front, on condition that they shall return it, when called upon to do so, in the same good condition in every respect as received.

During the present year, from about the 1st of September, it is proposed to employ the dredge on the work at Red Fish Bar, Galveston Bay; afterwards on the work at Calcasieu Pass, Louisiana.

The tug-boat will also be employed when required on these works, and, besides, be employed on the survey of Galveston Harbor, and the works of improvement in the harbor projected for this year.

Of the appropriation made by act of Congress approved June 10, 1872, as much as may be required (about $10,000) will be expended in making a survey of the harbor and entrance. The remainder will be applied in making the jettee, before mentioned, of a more permanent character than it now has.

Cash statement.

July 1, 1871, there was available from appropriations of 1870 and 1871	$44,823 24
From the appropriation of 1869, and to be returned to the United States Treasury	1,000 00
Total	45,823 24
There was expended during the past year	45,660 77
Leaving on hand	162 47
There was appropriated by act approved June 10, 1872	31,000 00
Total on hand and available	31,162 47
Deduct amount to be returned to appropriation of 1869	1,000 00
Leaving available for work this year	30,162 47

Of which about $10,000 will be applied to survey, and the balance to improvement of jettee.

An estimate for next year will be submitted after completion of the survey.

A project for this survey has been submitted and approved.

The work is not susceptible of permanent completion. It will, to a limited extent, benefit the commerce of Galveston.

The following statement of the commerce of that port has been received from the collector of customs, and is submitted, viz:

Number of entrances—steam-vessels, 257; tonnage	279,175
Number of clearances—steam-vessels, 242; tonnage	260,822
Total tonnage	539,997
Number of entrances—sailing-vessels, 338; tonnage	114,447
Number of clearances—sailing-vessels, 395; tonnage	129,659
Total tonnage	244,106

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Total value of imports, free and dutiable	$1,782,041 00
Total value of exports, domestic, to foreign countries	$10,818,281 00
Total value of exports, foreign, to foreign countries	159 00
Grand total of exports	10,818,440 00
Total amount of revenue collected on imports	$709,270 23

The work is located at the entrance to Galveston Harbor, in the collection district of Galveston, and near the light-house on Bolivar Point, Texas.

III.—IMPROVEMENT OF BAYOU TECHE, LOUISIANA.

My last annual report represented the wrecks and other obstructions cleared from the bayou, from its mouth to the town of New Iberia. Shortly after the rendition of this report work was suspended for a period, on account of high water in the bayou. When resumed, the work was commenced at the town of Saint Martinsville, the highest point on the stream to which improvement was contemplated, and from this point to New Iberia all obstructions were removed. Afterward, the stage of the water in the bayou being more favorable than at any previous period of the work, that portion of the stream below New Iberia was revisited, and some few obstructions that had before escaped notice removed, making altogether unobstructed navigation from Saint Martinsville to the Atchafalaya River, a distance of about seventy-five miles, being all that was contemplated by my instructions.

The results of operations during the whole time employed on the work are detailed as follows, viz:

Thirteen wrecks totally removed, viz, of steamers J. B. Cotton, Fly-Catcher, News Boy, Gossamer, Diana, Minerva, E. J. Hart, Andrews, and Guide; 2 schooners and 2 barges.

Three wrecks partially removed, viz, 2 steamers, Rob Roy and Iberia; 1 lighter.

One sunken raft, of 194 large live-oak logs, totally removed; 82 bridge-piles pulled out and removed; 24 dangerous snags removed; 38 overhanging trees cut and removed from banks; 4 live-oak roots, with dangerous stumps, removed; 106 large projecting limbs cut and removed; 39 projecting logs removed.

The work has given great satisfaction to all parties interested in the navigation of the bayou, and has benefited commerce to the full value of the money expended.

Financial statement.

Amount appropriated July 11, 1870	$17,500 00
Total cost of improvement	$12,477 52
Derived from sale of property and covered into Treasury	448 75
On hand in New Orleans, unexpended and covered into Treasury	573 73
Not drawn from United States Treasury	4,000 00
	17,500 00
Unexpended balance	$5,022 48

This balance would have been more than sufficient to have completed the work as originally planned. Better acquaintance with the wants of commerce, attained during the progress of the work, enabled me to modify the original plan. I decided the removal of underbrush from

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the banks at narrow points of the bayou both unnecessary and inexpedient; none was removed. Many trees, marked at the time of survey for removal, were left standing for the same reasons.

The scheme for conduct of the work was also modified, but one working party being employed, thus economizing on machinery, but extending the work over a greater period than was originally contemplated. This change was attended with marked economy, and no very serious inconvenience to commerce.

My acknowledgments are due to Mr. D. M. Kingsbury for his able and faithful superintendence of the working party. Without his efficient aid the work could not have been done so economically, perhaps not so thoroughly.

The work was located in the collection-district of New Orleans. The nearest light-house is located at the entrance to Atchafalaya Bay.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, United States Army.

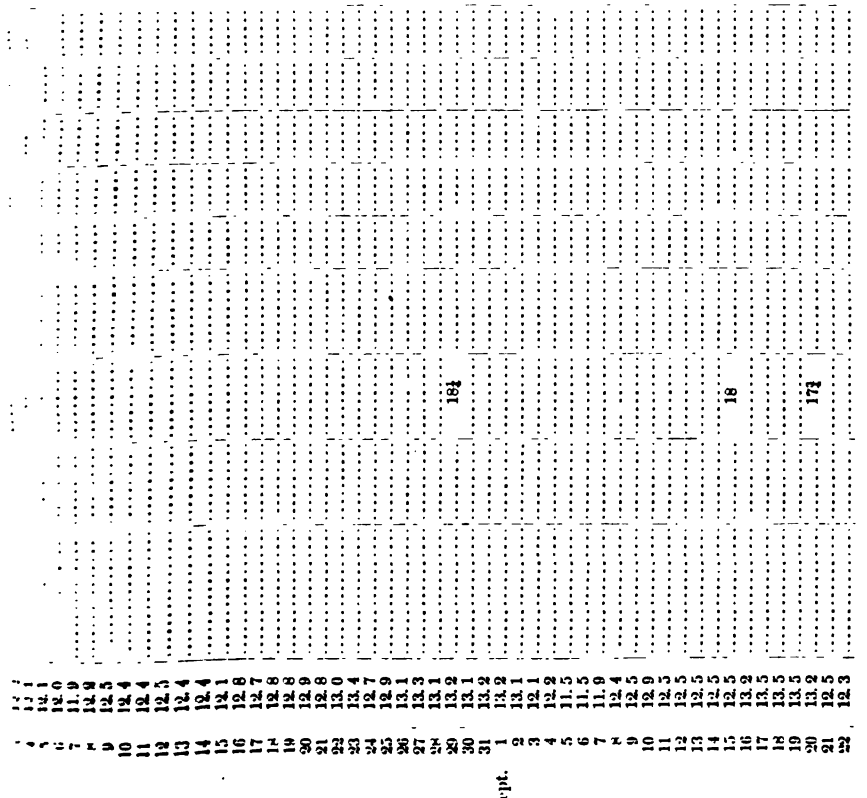
Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

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Tabular statement to accompany annual report for the year ending June 30, 1872, on the improvement of the mouth of the Mississippi River.

Date.	Stage of river at New Orleans—8 a. m.	Wind at South-west Pass.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Least width.	Number of vessels passed in.	Number of vessels passed out.	Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1871.	*Feet.*		*h. m.*	*Feet.*	*Feet.*				*Feet.*	*Hours*	
July 1	6.4		5 55	18¼		1	1				
2	6.4					4	9				No work; Sunday.
3	6.4					4	0				No work; channel in good condition.
4	6.4					1	3				Do.
5	7.2					2	1				Do.
6	7.6		3 30	18¼		2	1				
7	7.8		8	18.9		3	2				Barks J. Godfrey and Charles Auguste, bound in, ran aground, the Godfrey drawing 16 feet on west side of west channel, and the Auguste drawing 17 feet in middle of west channel, southwest of Cleopatra Buoy.
8	7.9	S. E.		18.9		1	1				
9	8.1					3	2	2	17	60	
10	8.3		9	17.6		1	1				Bark Sitka, bound in, grounded to westward, just below Wreck Buoy, was towed off and ran aground to eastward.
11	8.5					4	0				
12	8.9		8 50			2	1				
13	9.3		6 15			3	1				Least water found by Essayons coming in below Cleopatra Buoy, was 19.1 mean low tide.
14	9.8		6 30	18½		1	3				
15	9.8					2	0				No work; coaling, &c.
16	9.9					1	3				No work; Sunday.
17	10.3		7 15			2	0				
18	10.5					4	1				No work; rough weather.
19	10.8					3	2				Do.
20	10.8		3 25			4	2				
21	11.0	N. N. W.				1	4				No work; repairing machinery.
22	11.0	N.	9			3	6				
23	11.1					3	5	1	17	25	Ship Gardner Colby, drawing 17 feet, bound in, grounded on East Mud Lump.
24	11.3		2 58	18		3	3				
25	11.5										No work; Essayons started for New Orleans.
26	11.7										Do.
27	11.8										Do.
28	11.9										Do.
29	12.1										Do.
30	12.1										Do.
31	12.2										Do.
Aug. 1	12.3										Essayons at New Orleans undergoing repairs.

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Tabular statement to accompany annual report for the year ending June 30, 1872, &c.—Continued.

Date.	Stage of river at New Orleans—8 a. m.	Wind at South-west Pass.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Least width.	Number of vessels passed in.	Number of vessels passed out.	Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
	Feet.		*h. m.*	*Feet.*	*Feet.*				*Feet.*	*Hours*	
1871. Sept. 23	12.2										
24	12.5										
25	11.9										
26	12.5										
27	12.9										
28	13.2										
29	12.9										
30	12.5										
Oct. 1	12.5										Essayons at New Orleans undergoing repairs.
2	12.5										
3	11.9										
4	11.9										
5	12.5										
6	12.5										
7	12.9			17½							
8	12.9										
9	12.9										
10	12.9										
11	12.9										
12	13.0										
13	13.0										
14	12.9			17½							
15	12.9										
16	13.0										
17	13.0										
18	14.1										
19	13.9										
20	13.5										
21	13.9										
22	13.9										
23	13.9										
24	13.7										
25	13.7										
26	13.7										
27	13.7										

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	30	13.7												
	31	13.7												
Nov.	1	13.7												
	2	14.3												
	3	13.7½												
	4	13.2												
	5	13.3					18							
	6	13.3												
	7	13.7												
	8	14.0	S. W.											
	9	13.0	E.	2										
	10	13.7	N.											
	11	14.0	E.						1	4				
	12	13.8							4	8				
	13	13.2	S. S. E.	3					4	0				
	14	13.2	N. W.	6					1	2	1			
	15	13.5	N. N. E.	1	5				2	1				
	16	13.3	N.	1			17½		2	4				
	17	13.0	N. N. E.	2	4	30			4	0				
	18	12.7	E.	3					6	2				
	19	12.9	N. W.	1			18		6	7	1			10
	20	13.0	N. W.	1	8		18		7	4				
	21	12.9	N. N. W.	2					3	4				
	22	13.7	N. W.	1			18½		3	1				
	23	13.7	E. N. E.	1					3	3				
	24	13.7	S. W.	1					7	4				
	25	13.6	S. E.	1					2	1				
	26	13.7	S. E.	1					7	4				
	27	13.7	S.	1			19		4	2				
	28	13.7	S.	1			19		5	0				
	29	12.7½	N.	1			19		7	3	2	16	7	
	30	13.7	N. E.	1			19		5	3				
Dec.	1	12.7	N.	2			19		2	1				
	2	12.7	N.	1			19		5	2				
	3	13.2	W.	1					6	3				
	4	12.9	N. N. W.	6			19		2	2				
	5	12.7	N.	1			19½	95	4	2				
	6	12.9	N.	½			19½		2	2				
	7	13.7	S. W.	½			19¼		3	3				
	8	13.7	S. E.	1			19½		3	1				
	9	14	0	0			19½		5	7				
	10	13.7	N. W.	1					16	6				
	11	13.7	N. E.	1			20½		10	6				
	12	13.7	N.	½			20¼		7	3	1	16½		8
	13	14	0	0			20½		6	0	1			16
	14	14.3	N.	2			2[illegible]		3	8				
	15	14.3	N.	1			19		4	6	1	16½		37
	16	13.7	N. N. E.	½			19		3	6				

Essayons at New Orleans undergoing repairs.
Do.
Do.
Do.
Do.
Do.
Do.
Essayons started for Southwest Pass.
Essayons arrived at Southwest Pass.
No work.
Do.
No work; Sunday.
No work; rough on bar.
Steamer Saint Mary, bound in, grounded east of channel.
Least water found coming in, 18 feet 6 inches.
No work; coaling.
No work; rough on bar.
Ship Marcia C. Day, bound in, grounded to northward and eastward of East Mud-Lump Buoy.
No work; rough on bar.
No work; channel in good condition.
Do.
Do.
Do.
Do.
Do.
Ship Maxwell, drawing 15 feet 6 inches, bound in, grounded out of channel. Depth of channel abreast of ship, 19 feet.
Bark Hemia, drawing 16 feet, bound in, grounded on the Middle Ground.
No work; channel in good condition.
Do.
Do.
Do.
Do.
Do.
Do.
Do.
Do.
Do.
Ship Antarctic, drawing 16½ feet, bound in, ran ashore north of Wreck Buoy, west of channel, in 15 feet of water.
Steamer I. C. Harris, bound out, grounded east of channel.
Ship Canterbury, bound in, drawing 16½ feet, grounded in 12 feet of water, above East Mud Lump Buoy.

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Tabular statement to accompany annual report for the year ending June 30, 1872, &c.—Continued.

Date.	Stages of river at New Orleans—8 a. m.	Wind at Southwest Pass.		Hours worked by dredge-boat.	Depth of channel at mean low tide.	Least width.	Number of vessels passed in.	Number of vessels passed out.	Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1871.	*Feet.*			*h. m.*	*Feet.*	*Feet.*				*Feet.*	*Hours*	
Dec. 17	13.7	S.	1	.....	.....	.....	7	6	.....	.....	.....	No work; channel in good condition.
18	13.7	S.	½	.....	19	.....	4	3	.....	.....	.....	Do.
19	13.7	W.	1	.....	19	.....	6	3	.....	.....	.....	Do.
20	13.7	N.	3	.....	19	.....	6	7	.....	.....	.....	Do.
21	13.7	N. E.	2	.....	19	80	4	2	.....	.....	.....	Do.
22	14	S. E.	3	.....	19	.....	7	2	.....	.....	.....	Do.
23	12.7	S. E.	4	.....	19	.....	6	2	.....	.....	.....	Do.
24	13.7	.....	.....	.....	.....	.....	5	8	.....	.....	.....	Do.
25	14.2	.....	.....	.....	19	.....	5	1	1	11	.....	Steamer Rapidan, drawing 11 feet, bound out, grounded 500 yards east of channel in 10 feet water.
26	13.7	S.	1	.....	19	.....	6	1	.....	.....	.....	Essayons started for New Orleans.
27	13.7	S.	½	.....	.....	.....	.....	.....	.....	.....	.....	Essayons at New Orleans.
28	14.3	N. N. E.	1	.....	.....	.....	.....	.....	.....	.....	.....	Do.
29	14	0	0	.....	.....	.....	.....	.....	.....	.....	.....	Do.
30	14.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
31	13.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
1872												
Jan. 1	14.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
2	14.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
3	14.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
4	14.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
5	14.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Essayons started for Southwest Pass.
6	[illegible]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Essayons at Fort Jackson.
7	[illegible]7	N.	1	.....	.....	.....	.....	.....	.....	.....	.....	Essayons at Fort Jackson, Sunday.
8	13.7	N.	1	.....	.....	.....	3	0	.....	.....	.....	Essayons arrived at Southwest Pass.
9	14	N.	2	5 35	18	.....	8	3	1	17½	.....	Bark Kate Shilburnt, drawing 17½ feet, bound in, grounded just above East Mud Lump, in 14½ feet water.
10	14.1	N.	2	4 50	.....	.....	0	2	.....	.....	.....	
11	12.7	N. W.	1	.....	19	.....	1	2	1	17½	.....	Steamer Victor, drawing 17½ feet, bound in, grounded east of Cleopatra Buoy, extreme west side of channel, in 17 feet water.
12	13.9½	N. W.	½	.....	19½	.....	2	5	.....	.....	.....	
13	13.7	W.	½	.....	19½	.....	5	7	.....	.....	.....	
14	12.7½	N. W.	1	.....	19½	.....	6	3	1	18½	190	Steamer Statesman, drawing 18½ feet, bound out, ran ashore below pilot station, got off and ran ashore just above Stake Island, west of channel, in 10 feet water
15	12.7½	S.	1	.....	19½	.....	2	0	.....	.....	.....	
16	11.1	S.	1	.....	19½	.....	2	0	.....	.....	.....	

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	11	11 1	S.	1		19¼		4	7				No work; channel in good condition.
	12	11 3	N.	1				1	2				Do.
	13	12 1	W.	3				4	3				Do.
	20	12 7	N. W.	1		19¼		6	11				Do.
	21	12 7	N. N. W.	1				5	10				Do.
	22	12 7	N. W.	1		18½							Do.
	23	13 1	W.	1	1 5	18¼		4	0				
	24	13	N.	4	7 20			2	6	1	14	12	Steamer City of Galveston, drawing 14 feet, bound out, grounded near Wreck Buoy.
	25	12 3	N. N. E.	3				3	2				
	26	11 7	N. W.	3	4 40	19½		1	5				
	27	12 7	S. E.	1		19¼		0	0				No work; Sunday.
	28	12 7	N. W.	2		19½		10	12				No work; channel in good condition.
	29	12 1	N.	3		19¼		3	1				Do.
	30	13 7	N. N. E.	3		19½		7	3				Do.
	31	13 7	N.	1		19¼		2	3				No work; rough on bar.
Feb.	1	12 2	E. S. E.	5				5	2				No work.
	2	12 9	W.	1				0	2				Do.
	3	13 6	W.	2				1	1				No work; Sunday.
	4	13 9	N.	½		18¾		4	8				No work; foggy.
	5	14 1	E.	1				1	2				Do.
	6	13 4	S. E.	1		18¾		1	0				
	7	13 6	N.	2				3	5				
	8	13 3	N. W.	1				1	3				
	9	13 4	W.	½	5 45			1	1				
	10	13 6	N. E.	1		19		2	1				
	11	14 1	S. E.	4				5	3	1	18	19	Steamer St. Louis, drawing 18 feet of water, bound out, grounded on East Mud Lump in 14 feet of water.
	12	13 1	W.	1		18¼		5	11				
	13	13 2	W.	1		18¼		4	4				No work; rough on bar.
	14	13 6	N.	3	7 35	18½		1	0				
	15	14 1	S. E.	¼				2	5				Do.
	16	12 9	S.	2				0	4				No work; flood-tide not sufficient to carry sediment to sea.
	17	13 3	W.	¾		18		3	8	1		18	Steamer Chrosolite, bound out, grounded east side of channel.
	18	14 1	E.	¼				4	6				
	19	14 1	N.	1	7 50			5	10				
	20	13 9	E.	1				7	1				No work; rough on bar.
	21	13 2	S. E.	2				3	1				Do.
	22	14	N. N. W.	2	7 35	18¼		3	9				
	23	13 7	0	0	3 50	18½		4	2				
	24	13	S. E.	1				2	4				No work; rough on bar.
	25	13	N. N. W.	1				5	10				No work; Sunday.
	26	13	N. N. E.	1	7 40	18½		4	6				
	27	13 1	S.	1				0	4				No work; rough on bar.
	28	12 9						3	1				
	29	12 7	N. E.	1	3 15			5	9				
Mar.	1	12 7	N.	3				1	0				Do.
	2	13 1	N. N. W.	2				2	8				Do.
	3	12 9	N.	1				4	9				No work; Sunday.
	4	13 1	W.	1	2 10			2	6				
	5	12 7	S. W.	½	8			3	1				
	6	12 2	0	0	6 35			3	3				

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Tabular statement to accompany annual report for the year ending June 30, 1872, &c.—Continued.

Date.	Stage of river at New Orleans—8 a. m.	Wind at South-west Pass.		Hours worked by dredge-boat.	Depth of channel at mean low tide.	Least width.	Number of vessels passed in.	Number of vessels passed out.	Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1871.	*Feet.*			*h. m.*	*Feet.*	*Feet.*				*Feet.*	*Hours*	
Mar. 7	12.2	E.	1	5 10	.....	.....	5	4	.....	.....	.....	Least water found coming in 20 feet, tide 1 foot above zero.
8	11.7	E.	1	.....	.....	.....	5	1	.....	.....	.....	No work; foggy and rough on bar.
9	11.2	S.	1	.....	.....	.....	1	0	.....	.....	.....	Do.
10	10.2	N. N. W.	1	.....	19¾	.....	11	19	1	18	11	Steamer Koln, drawing 18 feet of water, bound out, grounded in 14 feet of water, just above East Mud Lump Buoy.
11	11.1	N. N. W.	3	.....	19¼	.....	4	3	.....	.....	.....	
12	11.7	N.	1¼	8 40	18	.....	6	4	.....	.....	.....	
13	11.7	E. S. E.	¼	.....	.....	.....	0	3	.....	.....	.....	No work; rough on bar.
14	12	S. E.	1	.....	.....	.....	4	5	.....	.....	.....	
15	12.1	S. W.	1	.....	.....	.....	0	2	.....	.....	.....	Do.
16	12.1	E.	1	1 15	.....	.....	3	7	.....	.....	.....	
17	12.3	0	0	.....	.....	.....	2	11	.....	.....	.....	No work; Sunday.
18	12.1	N.	2	8 30	19.4	.....	2	5	.....	.....	.....	
19	12	N.	¼	8 35	19.4	.....	9	3	.....	.....	.....	
20	12.2	N.	¼	5 55	.....	.....	4	5	.....	.....	.....	
21	12	N. N. E.	5	.....	19.4	.....	2	1	.....	.....	.....	No work; channel in good condition.
22	11.5	E. S. E.	2	.....	.....	.....	5	1	.....	.....	.....	No work; rough on bar.
23	11.2	N.	3	.....	.....	.....	5	10	.....	.....	.....	Do.
24	11.1	N. N. E.	4	.....	.....	.....	2	0	.....	.....	.....	Do.
25	10.2	E. S. E.	3	.....	20	.....	4	2	.....	.....	.....	Do.
26	10.2	N. E.	2	.....	.....	.....	6	9	.....	.....	.....	Do.
27	10.7	N. N. W.	1	.....	20	.....	11	11	.....	.....	.....	No work; channel in good condition.
28	10.9	W.	¼	.....	20	.....	2	3	1	18	16	Ship Wyoming, bound in, grounded to westward, just above Wreck Buoy.
29	10.9	N.	¼	.....	20	.....	4	8	2	17½	16	Ship Ella S. Thayer, drawing 17½ feet of water, bound in, grounded east side of channel. Ship Hermine, bound out, grounded just above Wreck-Buoy. Pilots report counter-current as cause of vessel's grounding.
30	10.7	E.	1	.....	20	.....	16	5	.....	.....	.....	
31	10.6	S. E.	1	.....	.....	.....	0	2	.....	.....	.....	
April 1	10.7	N.	1	.....	19	.....	12	5	.....	.....	.....	No work; channel in good condition.
2	11.3	E. N. E.	1	.....	19	.....	15	2	.....	.....	.....	Do.
3	10.3	E. S. E.	1	.....	.....	.....	1	0	.....	.....	.....	Do.
4	9.9	N. E.	1	.....	18½	.....	15	3	.....	.....	.....	Do.
5	9.9	E.	2	.....	18¼	.....	3	2	.....	.....	.....	Do.
6	9.9	E. S. E.	3	.....	18½	.....	1	4	.....	.....	.....	Do.
7	9.1	E. S. E.	4	.....	.....	.....	9	5	.....	.....	.....	Ship Chas. H. Southard, drawing 16½ feet, bound out, struck wreck at Wreck Buoy, causing leak. Schooners Mischief and Margaret Pollock ran ashore outside East Mud Lump.

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													Two barks bound in grounded east side of channel opposite Cleopatra Buoy, caused by Southard being ashore and throwing current to eastward.
		W.			18		5	12	3	16½		
		N.	1		18½		4	1	2			No work; sufficient water on bar.
		E.	1		18		2	2				No work; Sunday.
		E.	5		18		3	3				No work; heavy swell on bar.
		0	0		18		2	4				No work; rough swell on bar.
		E.	1				2	4				
		S.	½				6	3				
		W.	1		17½		3	11				Ship Manguam Dormio, bound in, drawing 18 feet, ran ashore east side of channel.
		S. E.	1	8 50	17½		4	6				
		S.	1	7 15	17		3	6				No work; Sunday.
		W.	2		17		4	6				
		S.	2	9 5	17½		2	2	1	18		
		S. E.	1				5	4				
		S. E.	2	6 0	17		1	3				
		N.	5	9 35	17½		1	1				
		N. W.	3	9 15	17½		6	6				
		N. E.	2	9 10	17½		1	3				No work; Sunday.
		N.	2	9 20	18		3	1				
		N.	1	9 15	19		3	12				No work; sufficient water on bar.
		0	0				2	1				
		0	0	8 45	19		1	2				
		E.	2		19		4	5				
May	1	E.	1		17½		1	4				No work; sufficient water on bar.
	2	N.	4		18		4	11				Do.
	3	N.	4	9 30	18½		2	2				
	4	N.	2	9 20			0	2				
	5	0	0		18		4	8				Ship Union, drawing 18½ feet, bound in, grounded between East and West Mud Lump. Found blade number 4 of excavating screw broken. How, when, or where broken not known.
	6	E.	2	9 55	18		6	2	1	18½		
	7	E.	1		17½		10	5				
	8	E.	3	9 40	18		7	0				
	9	E.	2	9 45	18½		2	5				
	10	E.	4				3	2				No work; heavy swell on bar.
	11	S.	2	9 20	19		2	8				
	12	W.	1				4	6				No work; Sunday.
	13	N.	1	9 30	19		3	0				
	14	E. N. E.	2		19.3		2	3				Essayons arrived at New Orleans.
	15	S. E.	3		18.2		1	5				Essayons at New Orleans.
	16	S. E.	3				1	2				Do.
	17	S.	3		18½		3	3				Do.
	18	S. W.	6				1	5				Do.
	19	E. N. E.	4				2	5				Essayons at New Orleans, taking out old and putting in new blades and pintles.
	20	E.	3		19½		3	0				Essayons at New Orleans.
	21	S.	3		18½		0	2				Do.
	22	S.	6									Do.
	23	S.	4				6	2				Do.

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Tabular statement to accompany annual report for the year ending June 30, 1872, &c.—Continued.

Date.	Stages of river at New Orleans—8 a. m.	Wind at South-west pass.		Hours worked by dredge-boat.	Depth of channel at mean low tide.	Least width.	Number of vessels passed in.	Number of vessels passed out.	Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1872.	*Feet.*			*h. m.*	*Feet.*	*Feet.*				*Feet.*	*Hours*	
May 24	5.8	S. E.	6	.....	.....	.....	1	2	.....	.....	.....	Essayons arrived at Southwest Pass.
25	5.2	S.	5	.....	.....	.....	0	9	1	.....	.....	Steamer Memphis, bound out, grounded, but got off without much delay.
26	5.3	S.	1	.....	.....	.....	2	6	.....	.....	.....	
27	5.3	S.	1	8 45	19	.....	2	1	.....	.....	.....	Essayons struck an unknown mud lump 600 feet outside West Mud Lump and broke blades numbers 1 and 4 close to hub.
28	5.3	0	0	.....	19¼	.....	.....	.....	.....	.....	.....	
29	4.9	.....		.....	.....	.....	.....	.....	.....	.....	.....	Essayons started for New Orleans.
30	4.8	.....		.....	.....	.....	.....	.....	.....	.....	.....	Essayons at New Orleans.
31	4.7	.....		.....	18½	.....	.....	.....	.....	.....	.....	Do.
June 1	4.6	N.	3	.....	.....	.....	.....	.....	.....	.....	.....	Do.
2	3.8	N. W.	1	.....	.....	.....	.....	.....	.....	.....	.....	Do.
3	4.2	0	0	.....	.....	.....	.....	.....	.....	.....	.....	Do.
4	4.3	S. W.	1	.....	.....	.....	.....	.....	.....	.....	.....	Essayons at New Orleans, repairing broken blades.
5	4.3	N. W.	5	.....	.....	.....	.....	.....	.....	.....	.....	Essayons at New Orleans.
6	4.3	N. E.	2	.....	.....	.....	.....	.....	.....	.....	.....	Do.
7	4.5	S.	4	.....	.....	.....	.....	.....	.....	.....	.....	Essayons arrived at Southwest Pass.
8	4.5	S.	3	.....	.....	.....	0	5	.....	.....	.....	No work; rough on bar.
9	4.4	S.	1	.....	.....	.....	1	1	1	17.9	.....	Ship Thomas Harward, drawing 17 feet 9 inches, bound in, grounded east of channel, opposite Cleopatra Buoy.
10	4.7	S. S. W.	3	.....	.....	.....	1	0	.....	.....	.....	
11	4.7	N. E.	2	7 55	.....	.....	1	1	1	17	.....	Bark Michele Gelatola, drawing 17 feet, bound out, grounded in channel, just above Cleopatra Buoy.
12	4.8	W.	1	6 12	.....	.....	1	0	.....	.....	.....	
13	4.8	0	0	9 5	.....	.....	0	2	.....	.....	.....	
14	4.8	S. W.	2	9 0	.....	.....	1	1	.....	.....	.....	
15	4.8	S.	3	2 5	.....	.....	0	2	1	.....	.....	Bark, (unknown,) bound out, grounded east side of channel, just below Cleopatra Buoy.
16	4.8	N. N. W.	2	9 0	.....	.....	0	5	.....	.....	.....	
17	4.8	S. W.	3	8 30	.....	.....	1	1	1	14	.....	Steamer Alice, drawing 14 feet, bound in, grounded west of channel, just above West Mud Lump, caused by ship Thomas Harward being ashore and throwing current to westward.
18	4.8	N. N. E.	1	3 23	.....	.....	3	4	.....	.....	.....	
[illegible]	[illegible]	N. N. W.	[illegible]	[illegible]	17½	.....	[illegible]	[illegible]	.....	.....	.....	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	.....	.....	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50	[illegible]	[illegible]	.....	.....	.....	

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[illegible]	4.7	S. W.	[illegible]					2	0	1	19	...	Ship Rochester, bound in, drawing 19 feet, grounded east side of channel, northeast of East Mud Lump Buoy.
24	4.7	W. S. W.	2	...	...	...	...	1	2	...	...	...	
25	4.8	W.	1	9	15	18	...	0	0	...	...	...	
26	4.8	W. S. W.	1	7	10	18	...	0	4	1	19	...	Ship Charlotte, drawing 19 feet, bound in, grounded west side of channel.
27	4.8	S. E.	1	9	5	18	...	2	1	...	...	...	
28	5	E.	1	...	...	18¼	...	3	1	...	...	...	Dredge-boat Gen'l M. D. McAlester arrived at Southwest Pass from New Orleans.
29	5.3	E. S. E.	1	9	5	18	...	3	2	...	...	...	
30	5.3	E.	1	...	...	...	...	0	0	...	...	...	

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N 2.

NEW ORLEANS, *June* 12, 1872.

DEAR SIR: Your letter addressed to Messrs. Price, Hine, and Tupper, requiring their statement concerning *benefits to Bayou Teche* derived from works done under the special supervision of your office, was handed to me by these gentlemen for answer.

It is a pleasant duty to acknowledge that the work done, under your instructions, by Captain Kingsbury is complete in every respect, and restored once more that important stream, Bayou Teche, to navigation.

Captain Kingsbury, with commendable energy, removed every obstruction from the mouth of Bayou Teche to Fausse Pointe, a distance of 70 miles, consisting of some 20 steamboats' hulls, 3 gun-boats, not less than 50 logs or sawyers, and managed his work so economically as not to absorb the whole of the appropriation made by Congress, ($17,500.)

I certify that the job of removing these obstructions is perfect and well done; that public interest of that section of country has received therefrom immense advantages, and the navigation company which I represent hereby tender you and Captain Kingsbury their sincere thanks for the thorough manner in which this heavy task was performed.

In conclusion, I will further add that if the State appropriation of $30,000 had been as judiciously expended as the congressional, under your charge, the trees, overhanging live oaks, &c., would all have been removed, leaving a handsome balance, (unexpended,) but personal greed absorbed all of the State appropriation and left many trees standing.

With renewed assurance of high esteem and consideration for yourself and Captain Kingsbury, I remain yours, respectfully,

E. B. TRINIDAD,
Captain United States Mail-Boat and Superintendent A. M. T. Co.

Major C. W. HOWELL,
Captain of Engineers, New Orleans, Louisiana.

I take great pleasure in testifying to the facts stated by Captain Trinidad. From personal observation, during the work of clearing the Teche and since, it is not too much to say that the accomplishment of the work was more thorough and at less cost than any similar job I have ever examined.

Yours, very respectfully,

T. TUPPER,
President A. M. T. Company.

N 3.

IMPROVEMENT OF NAVIGATION IN RED RIVER ABOVE SHREVEPORT LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, Louisiana, April 29, 1872.

GENERAL: I have the honor to transmit herewith a preliminary report, submitted by Lieutenant E. A. Woodruff, giving a general plan, with estimates, for the improvement of navigation in Red River above Shreveport, Louisiana, and in the route from Shreveport to Jefferson, Texas, via Sodo and Ferry Lakes and Cypress Bayou. A sketch of that portion of Red River now obstructed by raft and of a portion of the route to Jefferson accompanies the report.

The recommendations made by Lieutenant Woodruff can only be discussed when his final report is submitted.

The facts elicited by his survey of the Red River "raft-region" show that its character has been thoroughly misapprehended by engineers, and that it has been a comparatively unknown country, even to the oldest settlers on its borders. The "great raft" itself dwindles down to a pigmy in comparison with the popular notion of its extent and constitution.

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Lieutenant Woodruff's careful personal examination of the whole country covered by his survey eminently qualifies him for deciding the relative value of the several plans heretofore submitted both for removing and for evading the raft. He recommends the removal. The plan of operations sketched is the best that can be devised. It is necessarily crude, but will be elaborated in the final report.

The estimates are as good approximates as can be made at this time.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, United States Army.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

UNITED STATES ENGINEER OFFICE,
New Orleans, Louisiana, April 25, 1872.

SIR: I have the honor to submit the following preliminary report on the surveys of Red River and Cypress Bayou, in compliance with your order accompanying a telegram from the Chief of Engineers, dated April 18, 1872. The object of this report being to supply such information as has been obtained by the survey, especially with regard to the improvement of the navigation of Red River from Shreveport to the river above the raft, and of the lakes and Cypress Bayou to Jefferson, Texas, the general results only of the survey are herein given, with a statement of the plans and estimates for such improvements as are recommended. A sketch of the raft-region of Red River is transmitted herewith; also, a sketch of the lower end of Sodo Lake, pertaining to the improvement of Cypress Bayou navigation. A general map of the whole region from Shreveport, Louisiana, to Jefferson, Texas, and to the head of the raft, is in preparation, but cannot be completed for this preliminary report. The sketch of the raft shows accurately the portion of Red River obstructed by floating raft and "tow-heads," with characteristic soundings made at the time of the survey. The total length of raft covering the whole breadth of the river is seven miles, but throughout almost all of the distance between the head and foot of the raft the channel is partially obstructed. The whole area of floating raft is computed at 290 acres. The whole area of "tow-heads," or raft resting on the bottom and above water at the time of the survey, is computed at 103 acres. According to your letter of instructions, dated October 17, 1871, the object of the survey of the raft-region is to determine which of two general methods of improvements is more feasible: the removal of the raft obstructions from the main channel or the opening of some route around them. The latter plan was recommended, and work upon it done by Mr. Charles Fuller, United States agent, under Colonel J. E. Johnston, Topographical Engineers, in 1854–'55. The route selected was through Dooley's Bayou, Shift-tail Lake, Sodo Lake, and Twelve-mile Bayou. A survey and careful examination of this route have been made, as well as of all other possible routes on the west side of the river. The details will be fully given in the report to accompany the completed maps, but the results only are here stated. All of such routes are rejected as impracticable, for the following general reasons:

1. The route to be opened should not only afford passage for boats at moderate stages of water, but should have sufficient capacity (depth being the more important) to carry the drift which will continue to come from the upper river till the sources of its supply are destroyed. To give such capacity would require extensive excavations in the clay formations through which any such route would pass, involving great expense for digging or dredging.

2. Such a route would necessarily be much shorter than the main river, giving a greater fall per mile from its head at the river to the lakes. At several points it would have difficult rapids, and the freshets of the upper river would be brought down so quickly that the time of high water in it and the river would be greatly decreased. It is probable that any such channel would, on this account, require as high water for navigation as do the present routes, opened under charters from the State of Louisiana.

3. The channel of the main river affords a greater and more uniform depth than can be given to any other route for the cost of removing the raft, and can therefore be most easily adapted to the carrying of new formations of raft. It would afford incomparably better navigation than any other route and for a much longer time after each rise.

That the removal of the raft and the prevention of its re-formation is desirable, hardly admits of discussion. The need of a cheap mode of transportation of the products of the upper river, the relief of valuable plantations made worthless by overflow,

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and the prevention of the ruin of more valuable plantations above, are sufficient reasons to warrant extensive appropriations for these ends, provided it be shown that the work is practicable within reasonable limits of expenditure. The only objection likely to be raised, except that of expense, is the anticipated injury to the lake and bayou navigation to Jefferson, Texas.

The people of that city are naturally anxious to secure their present facilities and to improve them. Even if their apprehensions were well grounded, they would form an insufficient reason for allowing the ruin caused by the backing up of the water above the raft to spread over the productive valley below Fulton; but it is susceptible of demonstration that the decrease of the water in the lakes, caused by opening the main channel of the river, must be very gradual, and that the injury to navigation may be entirely counteracted by means not too expensive to admit of practical application. Such a demonstration will be attempted in the completed report, but here the means only for carrying out desired improvements are indicated, with such estimates as the time and the unfinished state of the maps have enabled me to prepare. To make intelligible the methods recommended for the removal of the raft, it is necessary to explain the nature of the obstructions found in it. Beginning at Carolina Bluffs, the foot of the raft, we find, at low water, an almost complete dam, consisting of a row of tow-heads, extending across the river, between which the water flows rapidly. These tow-heads are formed during freshets by an accumulation of the logs and drift-wood, of which the raft is formed, around some snag, which checks their progress down the river. As the water falls the pile rests on the bottom, and a rapid deposition of mud takes place around it. The surface left above water produces willows which grow rapidly and bind the mass more firmly together by their roots, which also protect the deposit from the washing of subsequent freshets. The willows found on the tow-heads of this oldest part of the raft are none of them larger than 10 inches in diameter. As shown by the map, the tow-heads are found principally below Dooley's Bayou, in which part of the river they form the principal feature of the raft obstructions. Generally they are islands, but frequently project into the channel from one side, greatly narrowing the water-way.

Above Dooley's Bayou floating raft is more common, and above Red Bayou the tow-heads entirely disappear and the greater areas of floating raft are found. But throughout all the raft much of the material of which it is composed is water-logged and sunken, so that one end rests on the bottom. If cut into short pieces, the heavier ends, usually the stumps, would sink, while the lighter parts would float. In removing the raft, therefore, all water-logged trees and stumps must be removed from the channel and deposited where they will not be liable to obstruct navigation. Only a small proportion of the tow-heads will float, and as they are made up of piles of drift-logs and red mud, their removal presents the greater difficulty. The river below Carolina Bluffs is much narrower than formerly, and its sides fringed with willows which would impede the passage of large bodies of floating drift. If the raft were removed and a new run of drift brought down by a freshet, it would doubtless jam in some part of the narrow river below Dooley's Bayou, or in the vicinity of Carolina Bluffs. Therefore the banks of the narrow part of the river should be cleared of trees, in order that the caving of banks and enlargement of channel may go on as rapidly as possible. The river above the raft supplies material for new formations. This supply should be stopped, or at least diminished. This would require the cutting of all snags, and dead trees, lying on sand-bars or on the banks, which are likely to fall into the river. Cotton-wood trees, when deadened, decay so rapidly that if their falling into the river be delayed two or three years, they will not be likely to form raft. The work to be done is, therefore, of three kinds:

1. Clearing of banks and bars above and below the raft.
2. Removal of tow-heads, or sunken raft.
3. Cutting up and removing floating raft.

For the first work a party of axmen will be needed below the raft, and a larger party or two parties, above the raft. The work below the raft need not extend below Shreveport. From what I can learn by inquiry, the work above should extend two or three hundred miles above the head of the raft.

For the second work I submit the following plan: Build a strong double-hull scow 100 feet in length, each hull having 20-foot beam and 36-inch hold; space between hulls, 10 feet, each hull to have a steam-capstan, worked by a nigger-engine, which can also be used for sawing snags when raised; the pair to be provided with strong shears and all convenient appliances for lifting sunken raft and sawing it up; this boat to be towed by a light-draught steamboat, furnished with a steam-crane on the bow, to be used in discharging on the bank such water-logged raft as may have been cut upon the double boat; apparatus for blasting the tow-heads and battures to be provided; but whether the use of any explosive compound for this purpose will be economical or not can be determined only by experiment. From their structure and situation, I think it probable that blasting will facilitate their removal. This work should begin at the foot of the raft. The plan here recommended was suggested to me by the apparent

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necessities of the work, which can be done to best advantage in low water, when light-draught boats will be required. I have since learned that a similar plan has been recommended for the removal of snags in the Arkansas River, in a report of Captain David Hiner, transmitted by Colonel Macomb to the Chief of Engineers with his report for 1868. (See report of Chief of Engineers, 1868, p. 596.) To Captain Hiner's report I am indebted for estimates of cost of working.

For the third class of work different appliances are required for greatest economy.

I submit the following description of a saw-boat, devised for cutting up floating raft, with auxiliary boats for removing the water-logged parts of the trees cut. One stern-wheel boat, of 175 feet in length, 40 feet beam, and 5 feet hold, furnished with sloping sides or aprons for a distance of 100 feet from the bow, the bow also to be furnished with an apron; these aprons to have a slope of 45° to the water, and to be furnished with cross-cut saws at intervals of 20 feet, connecting at pleasure with shafts under the deck, run by a small engine for that purpose, one shaft parallel to each side and one across the bow; the bow to be furnished with two steam-capstans, and the deck with a steam-crane, all worked by one large nigger-engine in the bow, and each connecting at pleasure with the engine. Movable shears, for lifting at bow or sides, also to be provided. The manner of working this boat would be as follows: Beginning at the lower end of a field of floating raft, some of the larger logs would be drawn by the steam capstan or crane to the sides and bow, where they would be cut up by the adjustable cross-cut saws, and the pieces allowed to float down stream. The power of the boat would also be used at times to break loose and scatter the raft. Large trees will frequently be found, the roots of which rest on the bottom, while the top is out of water. The part long under water will not float, and, if allowed to sink where cut up, may prove dangerous to boats in low water. To dispose of such logs, it is proposed to have a strong scow, managed by a small stern-wheel steamboat, in readiness to receive the heavy cut logs, which can be lifted by the steam-crane of the saw-boat, the small tow-boat to be also provided with a steam-crane for unloading the scow at the bank, when no suitable place for dumping the load can be found near at hand. In the last work of removing the raft, undertaken by Mr. Thomas T. Williamson, in 1841, the side-wheel boat Eradicator (which had been used by Shreve) was used. This boat had an apron at the bow, up which the logs were drawn by a steam-windlass. When conveniently upon the apron, they were sawed by hand into lengths of about 20 feet. The stumps, which were too heavy to float, were disposed of with much loss of time, by being taken on the boat to some bayou or lake where they could be dropped out of the channel. In the boat proposed, the sawing could be done by steam-power, without lifting the logs entirely from water until sawed, when those parts likely to sink could be removed on the scow provided for the purpose, without interrupting the progress of the saw-boat. Mr. Williamson also employed men to go upon the surface of the raft, by means of long planks, and saw all logs within reach into short lengths.

He says that a saw working down into the water will cut fully twice as fast as when entirely out of water. I am led to recommend stern-wheel boats because of their greater economy in running and less exposure to injury in the raft, as well as on account of the greater deck and side room which they afford. Supposing the plan here submitted to be adopted, it remains to consider the amount of running expenses and the rate at which the work can be done. Estimates of probable cost of boats and machinery and running expenses for one year are appended. Only trial can determine the rate at which any machinery or work can remove the obstructions, and to specify the time in which the method recommended can complete the work would be mere guess-work, or, at best, an estimate based upon uncertain *data*.

Assuming such *data* as the survey affords, and supposing that the work be carried on under competent and faithful supervision, the estimates which I have made lead me to think it possible to open a navigable channel in one year of work. Work done in clearing the channel from the foot of the raft up would not be lost, even if the whole were not at once completed. If the main river were opened to Red Bayou, a choice would be given between the two side routes now in use at lower stages of water than now required for boats to pass up Black Bayou. The channel would gradually improve its capacity for carrying raft, and, when the whole of the present raft is disposed of, need not again be allowed to choke up. Suppose the channel entirely open and the supply of drift above not stopped. In the event of any great run of drift appearing in the upper river, it might be boomed at some place above Red Bayou, probably above Alvan's first canal, or just below Hervey's Canal, where it could be destroyed at leisure and stowed in Simpson's Lake. In the mean time, navigation would not be suspended, as there would be a good route from Red Bayou through Posten Bayou, or, better, through Stump-Dam Bayou, Kelly Bayou, Scott's Slough, and Koun's Canal. The estimate of work required after the first opening of the channel is still more difficult, and can be based only on judgment as to time that the boats would be kept at work, which would vary with the runs of drift caused by freshets. Ample work for the large boats (double scow and saw-boat) could be found for some years in removing snags throughout the whole length of the navigable river. The saw-boat would be

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efficient as a snag-boat when not at work on floating raft. The following are estimates of cost of boats, machinery, and work, based on the plans submitted above:

Estimates for machinery and work for removing the Red River raft.

1. One stern-wheel saw-boat, fitted with ten saws on sloping sides and bow, two steam-capstans, with equipage complete	$57,350
2. Stern-wheel tender to saw-boat, with steam-capstan and steam-crane, for removing water-logged snags from saw-boat	1,000
3. Double-hull scow, with lifting and sawing apparatus, and small engine for working same	15,000
4. Stern-wheel tow-boat for same, with one steam-capstan and steam-crane, for unloading water-logged snags	15,000
Total machinery and boats	98,350

Estimate for work for one year.

No. 1 saw-boat, at $5,000 per month	$60,000
No. 3, with No. 2, at $1,000 per month	12,000
Nos. 4 and 5	20,000
Ax and saw party above raft	12,000
Ax and saw party below raft	3,000
Repairs of machinery, 10 per cent. on cost	9,850
Total work and repairs for one year	116,850

Summary for one year.

Boats and machinery	$98,350
Work and repairs	116,850
Contingencies, 20 per cent	43,162
Total	259,014

Subsequent expense of keeping river clear of raft and improving channel may be estimated, for first year after opening of channel, $50,000. Afterward the expense will decrease rapidly, but for several years the work of destroying raft-material and guarding against jams must continue, at an annual expense of from $10,000 to $25,000.

CYPRESS BAYOU.

The survey for improvement of Cypress Bayou includes properly the whole route from Shreveport, Louisiana, to Jefferson, Texas. From Shreveport to the head of Willow Pass, (the upper end of Sodo Lake,) the route is identical with that of boats for the upper river. At this point boats for Jefferson turn to the west into Fairy Lake, and by a tolerably direct course, in high water, reach the present mouth of Cypress Bayou west of the Texas line. From the mouth of Cypress Bayou (Bois d'Arc Pass, or the Ox-bows) to Jefferson, a distance of twenty-seven miles, the channel is well defined, and nearly all of the way has banks above water, except in freshets from the valley of this stream or high water of the lakes from Red River overflow. A survey of this bayou, with transit and level lines, has been made and extended across Fairy Lake to the south side, along which it is continued, to connect with the west line of the Red River survey at the head of Willow Pass. The map, as before stated, cannot be furnished with this preliminary report.

The route consists of four distinct divisions, viz:

1. Twelve-mile Bayou, from Shreveport to the foot of Sodo Lake.
2. Sodo Lake to the head of Willow Pass.
3. Fairy Lake to Bois d'Arc Pass, or mouth of Cypress Bayou.
4. Cypress Bayou to Jefferson.

Considered as levels in some of which slackwater navigation may be desirable, the division is slightly different. Twelve-mile Bayou is a rapid stream, but deep and crooked, always affording tolerable navigation to Albany, at the foot of Sodo Lake. Sodo Lake may be considered a level for slackwater navigation from Albany to the head of Willow Pass, having a fall in that distance of 1.63 feet at the time of the survey. From Willow Pass the level of Fairy Lake extends throughout the whole lake and up Cypress Bayou to Smithland. From Smithland to Jefferson, a distance of six miles, the water is shoal, and its depth more dependent upon the stage of Cypress Bayou

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above this point than upon the lakes below. The improvements of which the route is susceptible consist of removing stumps and snags, dredging, (which is required near Jefferson,) and giving slackwater navigation in Sodo Lake and Fairy Lake by dams, alone or with locks. In the event of the removal of the raft, I would respectfully recommend building a dam on the lines A B and C D, shown on sketch of the lower end of Sodo Lake, accompanying the sketch of the raft-region. It may afterwards be found desirable to narrow the water-way at the bluff by extending the dam from the island and main shore. Should these means fail, a lock can be constructed at this point, but if the chute be found to answer it will be cheaper and better. Other possible improvements, in controlling the flow of water into the lakes, will be indicated in the report accompanying the completed map, but as their need will depend upon the ascertained results of a successful removal of the raft, it is not necessary to consider them at present. If the raft be removed, the closing of Dooley's or any western canal or bayou above it should be prohibited, both as a measure of safety for the plantations on Red River below the raft and for the benefit of the lake and bayou navigation to Jefferson.

While at Jefferson, I was assured by the mayor that the city dredge would be placed at the disposal of the Government, if any appropriation were made to run it. The dredge is a very powerful one, by Atkins and Burgess, Chicago, and in good order. It could be employed to advantage on the shoal and narrow channel of Cypress Bayou, between Jefferson and Smithland. From the mouth of Cypress Bayou, in Fairy Lake, the deepest water is not found in the steamboat route, but through a cypress brake near Potter's Point, on a nearly direct line to Rocky Point. This route could be opened at a cost of about $3,000, and would greatly improve navigation at this end of the lake. Many stumps are found in Cypress Bayou, which could be removed, with advantage to navigation, at small expense. For the dam at the foot of Sodo Lake, pile-work will be cheapest, and in the clay bottom at that place can be built securely. In case any pile-work is needed in this region, I would recommend that permission be obtained for the officer or agent in charge of the work to cut timber from the public lands above. In this way only is it probable that the Government will derive any benefit from its timber in this vicinity, which is cut as fast the market at Shreveport demands. The following estimates for work on the Cypress Bayou route are respectfully submitted:

Estimates.

For work in removing stumps in Cypress Bayou and opening route from Bois d'Arc Pass, through cypress brake, near Potter's Point, it is recommended to build a flat-boat 80 feet long, 20-foot beam, 3-foot hold, and provide it with a small steam-engine suitable for running a saw for cutting off snags or stumps under water. Movable shears and lifting-apparatus also to be furnished.

Total cost estimated at	$5,000
Cost of running same, with superintendent and eight men living on boat, one year	12,000
Extra cost of opening new route in lake	3,000
	20,000

If the city of Jefferson will furnish dredge, running expenses of same six months, $12,000.

If it be decided to remove the Red River raft: For building dam at foot of Sodo Lake, to contract water-way at low stages, $70,000.

Commercial reports pertaining to Shreveport and Jefferson will be furnished in the completed report.

I remain, very respectfully, your obedient servant,

E. A. WOODRUFF,
First Lieutenant of Engineers, U. S. A.

Captain C. W. HOWELL,
Corps of Engineers, U. S. A., New Orleans, Louisiana.

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APPENDIX O.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDED JUNE 30, 1872.

IMPROVEMENT OF HARBOR AND BAY OF MOBILE, ALABAMA.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, July 31, 1872.

GENERAL: I have the honor to submit the following report of improvement of harbor and bay of Mobile, Alabama, for the fiscal year ending June 30, 1872.

The improvement of the harbor and bay of Mobile was commenced under the charge of the late Major C. B. Reese, in August, 1870, and the project for carrying on this improvement, submitted by him under date of August 5, 1870, was approved by letter of the Chief of Engineers, dated August 18, 1870.

Under this project the work since December 3, 1870, when I took charge, has been prosecuted by me with a modification as to the width of the channel, as recommended in my report, dated December 26, 1870.

At the beginning of this fiscal year, the work of dredging in Choctaw Bar Channel was continued by the contractor, Mr. John Grant, under the act of Congress of July 11, 1870, appropriating $50,000 for the improvement, the time of his contract having been extended to August 31, 1871, by authority contained in letter from Chief of Engineers, dated June 28, 1871. In accordance with recommendation from this office, under date of August 26, 1871, a further extension of time was granted the contractor, Mr. John Grant, by authority from the Chief of Engineers, contained in telegram dated August 30, 1871, under which Mr. John Grant continued to work until the completion of his contract, April 17, 1872.

On July 22, 1871, the contract awarded to Messrs. S. N. Kimball & Co., of Chicago, Illinois, for dredging Choctaw Bar Channel to a depth of 13 feet at mean low water, and part of Dog River Bar Channel to the same depth, at 39½ cents per cubic yard, under the act of Congress of March 3, 1872, appropriating $50,000, was signed, but owing to delays in the construction of dredge and scows, caused by a railroad accident delaying reception of machinery from Chicago, and the freezing of their tug-boat in the Illinois Canal, the contractors did not commence work until January 2, 1872, when one of their improved Osgood dredges was started in Choctaw Bar Channel, and continued to work in that channel until June 11, 1872, when the dredge was moved to Dog River Bar Channel.

It is to be regretted that the work of dredging Choctaw Bar Channel to a width of 200 feet, and a depth 13 feet, could not be completed on account of some piles, and an old wreck, encountered by the dredge in the gap of the upper obstructions. Only, however, about 8,000 cubic yards remain to be excavated in this channel on this account.

In January last, the dredging in Choctaw Bar Channel was so far advanced that all vessels coming up to the city since have been towed over this bar, and the circuitous channel through Spanish River has been abandoned, and a difference of twelve miles of distance saved.

The State board of harbor commissioners, authorized by an act of the legislature of Alabama, is now engaged in removing the remaining

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obstructions in the upper gap, and as soon as this is accomplished the dredging of Choctaw Bar Channel will be completed, and the balance available expended in dredging Dog River Bar Channel.

It is believed that with the funds on hand, viz, the new appropriation, by act of June 10, 1872, of $75,000, and the funds disposable by the State harbor board, a clear cut, of 60 feet wide and 13 feet deep at mean low water, will be made during the next fiscal year through Dog River Bar, and thus vessels of this draught, in higher stages of the water, be enabled to reach the wharves of the city from the bay.

The following statement will show the progress of the work under both contracts, from June 30, 1871, to June 30, 1872:

Amount excavated by Mr. John Grant:

	Cubic yards.
July, August, and September, 1871	7,500
October, November, and December, 1871	10,459
January, 1872	5,510
February, 1872	4,209
March, 1872	5,491
April, 1872	2,785

Amount excavated by S. N. Kimball & Co.:

January, 1872	5,490
February, 1872	7,229
March, 1872	8,850
April, 1872	15,775
May, 1872	16,948
June, 1872	17,717
Making the total amount excavated during the year	107,963

Financial condition.

Amount appropriated by act of July 11, 1870	$50,000 00
Amount appropriated by act of March 3, 1871	50,000 00
Total	100,000 00
Amount expended during the fiscal year ending June 30, 1871	20,714 76
Balance available July, 1871	79,285 24
Amount expended during the fiscal year ended June 30, 1872	58,705 39
Difference	20,579 85
Deduct 20 per cent. retained on contract of S. N. Kimball & Co., yet unpaid	5,688 70
Balance available of old appropriation July 1, 1872	14,891 15
Add appropriation by act of June 10, 1872	75,000 00
Total amount available July 1, 1872	89,891 15

Since my last report the channel over Dog River Bar has been permanently located, and, from the soundings taken on the located line, I submit the following:

Estimate of work remaining to be executed June 30, 1872.

	Cubic yards.
Completion of Choctaw Bar Channel	8,000
Dredging Dog River Bar Channel, 200 feet wide by 13 feet deep at mean low tide, a length of 38,400 feet, average depth of excavation 3.6 feet	1,024,000
Total	1,032,000

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1,032,000 cubic yards dredging, at an average cost of 50 cents	$516,000 00
Add 5 per cent. for engineering and contingencies	25,800 00
Total estimated cost of work required for a channel 200 feet wide and 13 feet deep at mean low water, from June 30, 1872	541,800 00
Deduct amount available as above, June 30, 1872	89,691 17
Balance required to complete Dog River Bar Channel	451,908 83
Amount required for the fiscal year ending June 30, 1874	$200,000 00

In this connection it may be proper as a matter of history, and because of the principles involved, to state the following facts:

Soon after my return to Mobile, November 1, from sick-leave, I found that the State board, without any consultation with this office, was proceeding on plans of improvement of the harbor in direct conflict with those which had been approved by the General Government, and which they had by letter from their chief engineer, General Braxton Bragg, dated 27th February, 1871, to me, agreed on their part not to conflict with.

These plans were:

1st. A jettee, to be 1,400 feet long, extending southerly from Pinto Island.

2d. A main canal extending northwardly, through Pinto Island and dividing it nearly equally, and three auxilary canals; the object being, with the aid of the increased flow of water to be effected by closing up Pinto Pass, to so operate on the west half of Pinto Island as to scour it away, and thus give a larger water-way between the island and the city, for Mobile River.

3d. The construction of a jettee 4,000 feet long below Choctaw Point.

Feeling aggrieved at this extraordinary procedure, in a letter to General Bragg, dated November 21, 1871, I strongly protested against the works the State board were constructing, and had contracted for, and in a report to the Chief of Engineers, United States Army, dated December 16, 1871, I gave my reasons therefor as follows:

1st. That without any consultation with this office, and contrary to a written guarantee, they were operating on plans which had not been approved by the United States Engineer Department.

2d. That the effect of the proposed works, which was to get a straight channel over Choctaw Point Bar, would certainly change the present channel to such a degree as to render entirely useless all the expense which had been already incurred, and was then being incurred, under an existing contract with Mr. John Grant, and to be incurred under the new contract with Messrs. S. N. Kimball & Co., which had especial reference to the present channel.

3d. The proposed plans of the State board would so derange the present Choctaw Bar Channel, by filling it up, and possibly not for months, if at all, effecting a better channel, that the probabilities were, the commerce of this point would be very considerably deranged and damaged by said plans.

4th. Admitting that the effect of the plans would be to scour away the west half of Pinto Island and a large portion of Choctaw Point, it must be evident that the drifting down of so large an amount of material would very seriously damage the channel below Choctaw Point, no matter at what place it would finally be deposited; and this because of the great shallow expanse of the bay at lower end of Choctaw Channel.

The result of my protest was the assembling in this city of a board of United States engineers under the following:

[Special Orders No. 4.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 6, 1872.

I. A board of engineers, to consist of Colonel J. H. Simpson, Corps of Engineers; Lieutenant-Colonel Z. B. Tower, Corps of Engineers; Lieutenant-Colonel H. G. Wright, Corps of Engineers, will convene in Mobile, Alabama, on January 20, or as soon there-

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after as practicable, to prepare a plan for the improvement of the harbor of Mobile. In connection therewith, the board will examine the projects of the "board for the improvement of the river, harbor, and bay of Mobile," organized under authority of the State of Alabama, and report their views as to the probable effect of the works projected by that board upon the operations now being carried on by the United States for the improvement of the Mobile Harbor, and upon those proposed by the plan they may submit for its improvement, and what modifications, if any, should be made in the projects of the State board.

Captain A. N. Damrell, Corps of Engineers, will act as recorder of the board.

* * * * * * * * * * *

By command of Brigadier-General Humphreys:

JNO. G. PARKE,
Major of Engineers.

The board met on the 3d of February, and continued in session from day to day, examining maps of the river and bay of Mobile, and projecting plans for their improvement, and such reports of boards and of officers of the Corps of Engineers as were at hand, and visiting the localities of interest connected with the projected plans of improvement. Their report was submitted to the Chief of Engineers, February 14, and as it has been published by Congress, and constitutes Ex. Doc. No. 64, Senate, Forty-second Congress, second session, it is not necessary for me to repeat it here; suffice it to say that it fully sustained my protest.

Subsequently, on the 16th of March, I received the following letter from the Chief of Engineers:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., March 12, 1872.

COLONEL: The report of the board of examiners constituted by Special Order No. 4, Headquarters Corps of Engineers, of January 6, 1872, to convene at Mobile, Alabama, to prepare a plan for the improvement of the harbor of Mobile, has been received, and approved by the Chief of Engineers and Secretary of War. You will accordingly conform to the views and recommendations of the board in all matters relating to the improvement of the harbor.

You will please furnish a copy of the report, with a copy of this letter, to the State board of harbor improvement.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers.

Colonel J. H. SIMPSON,
Corps of Engineers, Mobile, Alabama.

The correspondence of this office, consequent upon the foregoing instructions, was as follows:

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, March 16, 1872.

SIR: I have the honor, agreeably to letter from Brigadier-General A. A. Humphreys, Chief of Corps of Engineers, United States Army, dated Washington, D. C., March 12, instant, of which the inclosed is a copy, to furnish you with a copy of the report of the board of engineers constituted by Special Order No. 4, Headquarters Corps of Engineers, of January 6, 1872, to prepare a plan for the improvement of the harbor of Mobile.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, and Brevet Brigadier-General, United States Army.

PERCY WALKER, Esq.,
Secretary of Board for the Improvement of the River, Harbor, and Bay of Mobile.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, March 23, 1872.

GENERAL: On the 8th instant I had the honor to inform you that I had, as directed by you, furnished the State board for the improvement of the river, harbor, and bay of Mobile with a copy of the report of the board of United States Engineers recently convened in this city, by virtue of Special Orders No. 4, Headquarters Corps of Engi-

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neers, Washington, D. C., of January 6, 1872, for the purpose of preparing a plan for the improvement of this harbor. Since then there has been the following correspondence, a portion of which has already been communicated, but which I think proper to present in a connected form:

"OFFICE OF THE BOARD FOR THE IMPROVEMENT OF THE
"RIVER, HARBOR, AND BAY OF MOBILE,
"*Mobile, March* 18, 1872.

"SIR: I have the honor to acknowledge the receipt of your note of 16th instant, inclosing copy of letter of 12th instant to you from General A. A. Humphreys, Chief Engineer United States Army, and copy of the report of the board of engineers, United States Army, recently convened at Mobile, under Special Orders No. 4, from headquarters Corps of Engineers.

"At an early day the papers will be laid before this board, and its action thereon communicated to you.

"I am, very respectfully, your obedient servant,

"PERCY WALKER,
"*Secretary, &c.*

"General J. H. SIMPSON,
"*Engineer, United States Army.*"

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, March* 18, 1872.

"SIR: On the 16th instant, agreeably to authority from Brigadier-General A. A. Humphreys, Chief of the Corps of Engineers, United States Army, dated 12th instant, a copy of which was inclosed, I had the honor to furnish your board with a certified copy of the report of the board of United States Engineers, constituted by Special Orders No. 4, Headquarters Corps of Engineers, of January 6, 1872, to report a plan for the improvement of the bay of Mobile.

"The letter referred to also informed you that said report had been approved by the Chief of Engineers and Secretary of War, and that I have been directed to conform to the views and recommendations of said United States board in all matters relating to the improvement of the harbor.

"In yesterday's Register, a daily newspaper published in this city, I notice the following advertisement:

"'*To contractors.*

"'ENGINEER OFFICE, BOARD FOR THE IMPROVEMENT OF THE
"'RIVER, HARBOR, AND BAY OF MOBILE,
"'*No.* 38 *North Royal street, Mobile, March* 16, 1872.

"'Sealed proposals will be received at this office until 12 m. 20th March, 1872, for repairing and extending two jettees at the head of Spanish River.

"'Specifications of the work, with the terms and conditions, may be seen at this office from 9 to 3 o'clock, daily.

"'BRAXTON BRAGG,
"'*Engineer.*'

"The foregoing notice to contractors, showing that your board are contemplating the partial closing of Spanish River at its head, by repairing and extending two jettees at that point, which works are in direct conflict with the views and recommendations of the United States board, as shown in their report, as the General Government engineer officer in charge of the improvement of the harbor of Mobile, I respectfully but earnestly protest against the construction of any such works by your board, or of any other which will conflict with said report.

"I am, very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Brevet Brigadier-General and Colonel of Engineers, United States Army.*

"PERCY WALKER, Esq.,
"*Secretary of Board for the Improvement of the*
"*River, Harbor, and Bay of Mobile.*"

"OFFICE OF THE BOARD FOR THE IMPROVEMENT OF THE
"RIVER, HARBOR, AND BAY OF MOBILE,
"*Mobile, March* 18, 1872.

"SIR: Your note of this date, referring to the advertisement of General Bragg, engineer of this board, calling for proposals for repairing and extending two jettees at the head of Spanish River, published in the Mobile Daily Register of 17th instant, and protesting against the construction of that work, has just been received. Your note seems to have been written under the impression that this board had approved of said work after being informed of the report by the board of engineers recently convened in this city.

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"Permit me to disabuse your mind of this impression. The report was not received by me until this morning, an hour or two before I dispatched my note of this date, acknowledging receipt of yours of 16th instant, with its inclosures, and has not yet been seen by any member of the board.

"As my note of this morning stated, a meeting of the board will be speedily held for the purpose of acting on the report, and, without delay, you shall be advised of its action.

"Very respectfully,

"PERCY WALKER,
"*Secretary, &c.*

"General J. H. SIMPSON,
"*Engineer, United States Army.*"

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, March* 19, 1872.

"SIR: Your letter of 18th instant, acknowledging receipt of my letter of same date, protesting against the construction, by your board, of certain contemplated works at the head of Spanish River, and stating that a meeting of said board would speedily be held for the purpose of acting on the report of the United States board recently convened in this city, was received by me last evening.

"I am, very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Brevet Brigadier-General and Colonel of Engineers, United States Army.*

"PERCY WALKER, Esq.,
"*Secretary of Board for the Improvement of the*
"*River, Harbor, and Bay of Mobile.*"

"OFFICE OF THE BOARD FOR THE IMPROVEMENT OF THE
"RIVER, HARBOR, AND BAY OF MOBILE,
"*Mobile, March* 21, 1872.

"SIR: I have the honor to inform you that a meeting of this board was held this day, and your communication to me of the 16th instant, together with the letter to you from General A. A. Humphreys, United States Army, and the report of the board of engineers recently convened in this city, to prepare a plan of improvement of harbor of Mobile, was laid before it.

"The action of this board thereon will appear from the following extract from the minutes, a copy of which I was instructed to furnish you with.

"'General J. H. Simpson, engineer United States Army, stationed at Mobile, having, since the last meeting of this board, held on the 15th instant, communicated a copy of the report of the board of engineers, United States Army, convened at this city, under a special order from headquarters at Washington, D. C., to prepare a plan for the improvement of the harbor of Mobile, and it appearing from said report that the repair and extension of the jettees at the head of Spanish River, directed by this board at said last meeting to be made, are not in conformity with the plan of improvement proposed in said report, and approved by the Chief of the Engineer Corps and the Secretary of War, and this board not having power to carry out any scheme of improvement not sanctioned by the authorities of the United States, and regarding it as a duty to use the means at the disposal of this board in aid of the plan marked out in the report, therefore, and upon the suggestion of the engineer, the directions given at the said last meeting are hereby recalled, and the secretary is instructed to inform General Simpson thereof, and that this board holds itself in readiness to enter upon such portion of the work contemplated in the report as he may indictate, and he is respectfully requested to inform this board of such designation as soon as possible, in order that due preparations may be made by this board.'

"Very respectfully, your obedient servant,

"PERCY WALKER,
"*Secretary, &c.*

"General J. H. SIMPSON,
"*Engineer, United States Army, Mobile, Alabama.*"

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, March* 22, 1872.

"SIR: I have the honor to acknowledge the receipt of your letter dated yesterday, communicating the resolution formed by your board, same day, to the effect that they had recalled their order directing the repair and extension of the jettees at the head of Spanish River, and that they would, in subordination to the plan recommended by the report of the board of United States engineers, and approved by the Chief of Engineers and the Secretary of War, aid to the extent of the means at their disposal in the improvement of the harbor of Mobile.

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"I am gratified with the receipt of this resolution, showing, as it does, a harmony of action on the part of the State board and United States Engineer Department, which cannot but be productive of the happiest results.

"In accordance with the wish of the board that I should designate the portion of the work to be assigned to them in order that they may enter upon it at the earliest moment, I respectfully state that the lower portion of Dog River Bar Channel will be immediately staked out; and it is recommended that the board commence at the northern limits of the upper fleet anchorage, or 12-foot curve and dredge, to a least depth of 13 feet in the channel from that point, making, at first, one thorough cut (to the extent of the sweep of the dredges) from south to north, and that the material thus excavated be deposited as far on the west shore of the bay, say the 6-foot curve, as can be approached by the dumping-scows.

"The soundings have already been made over the said bar, but allowing for unfavorable weather at this season of the year, it is not believed the channel can be staked out ready for your operations till Monday, the 11th of April next.

"Very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Brevet Brigadier-General and Colonel of Engineers, United States Army.*
"PERCY WALKER, Esq.,
"*Secretary of the Board for the Improvement of the River, Harbor, and Bay of Mobile.*"

The foregoing correspondence showing that the State board recognize fully the paramount authority of the General Government to prescribe a plan for the improvement of the harbor, and that it is their purpose to aid in carrying out such plan agreeably to the report of the United States board, and to enter upon the work so soon as I shall indicate the portion to be assigned to them, and the following extract from said report setting forth the great necessity of large appropriations for the immediate and rapid excavation of Dog River Bar Channel, at present the only great obstruction in the channel of approach to the inner harbor, I respectfully and earnestly recommend that the appropriation I have asked for this object, in my last annual report, to wit, $100,000, be augmented at least to $200,000, and that this recommendation be laid before Congress at its present session, and at the earliest possible moment.

The following is the extract alluded to:

"As to the direction of this artificial channel the board concur with that of 1850, and with both the engineer officers in charge of the Mobile Harbor improvements, that the line of deepest water should be followed as it has existed for the past fifty years, since this line must now be regarded as a resultant of a fixed regimen of the different rivers uniting to produce this channel. The curve at the upper obstructions should be made as gentle as possible, and the opening or width of channel in that part somewhat increased, to admit the ready passage of the largest class of vessels that may enter the inner harbor of Mobile. It is recommended that this excavation be restricted to a width of 200 feet throughout its length, at least until its comparative permanency can be tested or established. *The board give it as their opinion that this excavation should be made as rapidly as possible*, for, if portions only are dredged and left in an uneven or lumpy condition, such portions will fill to the level of the projections, and, besides, there will not be a clear water-way for the ready movement of the bottom current until each bar is cut entirely through and finished to an even surface. If, on the other hand, this dredging should proceed slowly and at intervals, it will be but a partial success. No good results can be predicted except from a rapid and thorough execution of the work."

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, May 15, 1872.

SIR: I have the honor herewith to furnish your board with plan and profile of channel over Dog River Bar, from 13 feet of water in "upper fleet anchorage," of Mobile Bay, to 13 feet of water north of gap, in lower obstructions, making a total length of 38,400 feet. Only the east line of the channel has been staked out, and the soundings from which the profile is made have been taken on that line. At present the line is located by bush-stakes, but as these are liable to be carried away by passing vessels, I respectfully recommend that, preliminary to commencing dredging-operations, your board establish along the entire length of the channel, say 1,000 feet apart, a line of single piles, these piles to be placed at least 20 feet to eastward of the east line of the channel as staked out, and to show a length of at least 8 feet above mean

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low water. My assistant, Mr. R. Rauchenstein, is authorized, with his surveying party, to aid in this work.

As all large vessels, in going to and from the city, pass on the west side of the new channel, it is advisable to commence the work of dredging along the east line, where the dredges will not interfere with passing vessels; and that a cut about 60 feet wide, and the proper depth of 13 feet, be made along this line throughout its entire length, so that vessels can avail themselves of this cut while the channel is being widened westwardly to its projected width of 200 feet.

Should the State board conclude to assist in excavating this channel, I recommend that their dredges commence work at the south end of the channel and dredge north, a width of 60 feet along the east line, till they meet the Government dredges working south on the same line, and that then both turn back and widen the cut. By proceeding in this manner the work of both parties will be kept entirely separate, and all causes for complaint be avoided.

In conclusion, I would state, that during the time the surveying party was engaged in locating and sounding this channel, the weather was very unfavorable, not only delaying the work for weeks, but also interfering with the accuracy of the soundings, which will be tested whenever the weather will permit. The profile I send you, however, is sufficiently accurate to show the nature and extent of the work to be performed.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, United States Army.

PERCY WALKER, Esq.,
Secretary of the Board for the Improvement of the River, Harbor, and Bay of Mobile.

OFFICE OF THE BOARD FOR THE IMPROVEMENT OF THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, May 20, 1872.

SIR: I have the honor to inform you that your communication of the 15th instant, with accompanying plan and profile of channel over Dog River Bar, &c., was submitted to this board at a meeting held this day, and the following action had thereon, viz: "The secretary is instructed to inform General J. H. Simpson that in consequence of the inability of this board to negotiate the bonds of the county of Mobile, (and which constitute the only source of revenue of this board,) the work of dredging over Dog River Bar, designated by him in his communication of the 15th instant, cannot now be undertaken, but that as soon as this board is placed in possession of adequate means, he shall be informed of it."

I am, very respectfully, your obedient servant,

PERCY WALKER,
Secretary, &c.

General J. H. SIMPSON,
Colonel Engineers, United States Army, Mobile, Alabama.

ENGINEER OFFICE OF THE BOARD FOR THE IMPROVEMENT OF THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, May 25, 1872.

SIR: In acting upon your communication of the 15th instant, the State board was doubtless influenced in part, if not entirely, by the conviction of an inability, in their present financial condition, to accomplish the whole work proposed (the removal of Dog River Bar) on the plan laid down, and an apprehension that a part of it could not be made available.

To avoid if possible the necessity for suspending a work of such vital importance to this community, especially after so much has been successfully accomplished, I beg to ask whether we may not devise some programme for future operations by which available means may be so applied as to open a part of the channel proposed, reducing the depth or width as may seem best; thus securing a passage for larger vessels, and rendering still more useful the important success already achieved.

From a consideration of reports and suggestions heretofore made by you and your predecessors, I am inclined to the opinion that our united means can be so applied as not only to afford this great relief to commerce, but to open the way to larger and more important results.

Should you concur with me in these views, an expression of your opinion in such form that it may come before the State board in an authentic shape, will doubtless be followed by a modification of their late decision.

As the board meets on Monday, the 27th, an early reply is requested.

I am, general, very respectfully, your obedient servant,

BRAXTON BRAGG,
Engineer of the Board.

General J. H. SIMPSON,
United States Engineers.

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UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, May 25, 1872.

SIR: Referring to my letter of 15th instant to the secretary of the harbor board, and to your letter of the 25th instant, just received, in relation to proposed operations on Dog River Bar channel, I modify my recommendations in said letter of 15th instant, so far as that, instead of commencing the dredging of said channel at either end and working toward the center, I recommend that your board commence at the turn of the channel indicated on the plan and profile, and in place as "Double-Bush Stake," situated about 200 feet below the "Lower Bar Range Stake," and dredge to a least depth of 13 feet southward to the 13 feet water in the "Upper Fleet Anchorage;" and that the General Government dredge to the same depth from said "Double-Bush Stake" northward to 13 feet of water north of gap in lower obstructions; in all other respects the recommendations to remain the same as expressed in my letter of 15th instant. There is no doubt that by thus commencing and continuing operations the channel will be constantly ameliorating and the means available applied to the best possible advantage.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Brevet Brigadier-General and Colonel of Engineers, U. S. A.

General BRAXTON BRAGG,
Engineer of Board for Improvement of River, Harbor, and Bay of Mobile, Mobile.

ENGINEER OFFICE OF THE BOARD FOR THE IMPROVEMENT OF THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, May 30, 1872.

GENERAL: I am prepared to locate the line of excavation on lower Dog River Bar and drive the necessary piles for its more permanent designation, and shall be glad to avail myself of your offer to aid with the services of Mr. Ranchenstein and his surveying-boat.

Very respectfully, your obedient servant,

BRAXTON BRAGG,
Engineer of the Board.

General J. H. SIMPSON,
United States Engineers, Mobile.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, May 31, 1872.

GENERAL: I have directed Mr. Ranchenstein, my assistant, to see you and make arrangements for the establishment of the range of guide-piles for the excavation of the Dog River Bar channel, agreeably to plans referred to in my letter of 15th instant to secretary of the State board, and my letter to you of the 25th instant.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Brevet Brigadier-General, U. S. A., Colonel of Engineers.

General BRAXTON BRAGG,
Engineer of Board of the Improvement for River, Harbor, and Bay of Mobile, Mobile.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, June 1, 1872.

SIR: I inclose a tracing showing the exact position of some of the obstructions, ten in number, consisting of eight piles, one log, and one wreck, which yet remain in Choctaw Bar channel at the upper gap, and which require removal before the full benefit of 13 feet depth in the channel at mean low water can be obtained. As the tracing indicates the depth of water on these obstructions varies from 9 feet 2 inches to 12 feet 2 inches. There may yet be found other obstructions in the gap, which, as soon as ascertained, will be brought to the notice of the State board. As this board have undertaken the removal of all the obstructions in the two gaps, I respectfully request that those pointed out may be removed as soon as practicable.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Brevet Brigadier-General and Colonel of Engineers, U. S. A.

General BRAXTON BRAGG,
Engineer of Board for Improvement of the River, Harbor, and Bay of Mobile.

ENGINEER OFFICE OF THE BOARD FOR THE IMPROVEMENT OF THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, June 3, 1872.

GENERAL: Your communication of 1st instant, inclosing a tracing showing location of some remaining obstructions in upper gap, is received. Measures will be taken im-

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mediately to have them removed. The soundings over these piles show that they must have been covered several feet by mud at the time the gap was opened, and therefore it is not at all improbable others may be found. Should such prove to be the case, early information of their location will be thankfully received.

Very respectfully, your obedient servant,

BRAXTON BRAGG,
Engineer to Board, &c.

General J. H. SIMPSON,
United States Engineers.

In conclusion, I will state that at the letting of the contract advertised May 29, by the State board, for dredging a portion of Dog River Bar channel, I am informed S. N. Kimball & Co., of Chicago, Illinois, the present United States contractors on this improvement, were the lowest bidders, at 49½ cents per cubic yard, and that a contract has been closed with them.

Respectfully submitted.

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

P.S.—Since writing the foregoing, I find the following in the Mobile Daily Register of August 1, 1872:

MOBILE HARBOR.—THE NEW APPROPRIATION.

The secretary of our board of trade has received the following note from General Bragg, in answer to inquiries set on foot relative to the probable condition of our harbor next year. It will be remembered that it was principally due to the influence and active exertions of our board of trade that the $75,000 alluded to below was appropriated. This is the letter:

"ENGINEER OFFICE, BOARD FOR THE IMPROVEMENT OF THE
"RIVER, HARBOR, AND BAY OF MOBILE,
"*Mobile, July* 31, 1872.

"DEAR SIR: In reply to your inquiry on the subject of harbor improvement, it affords me pleasure to inform you that the work has progressed very satisfactorily since the last annual report by your board, and the prospect for the future is encouraging.

"The work on Choctaw Bar has been completed, and vessels drawing 15 feet can pass without difficulty at ordinary high tide. This obviates entirely all necessity for the expensive and circuitous route by Spanish River.

"The United States Engineer Department has been dredging on Dog River Bar for some weeks, and the contractors under this board will enter upon a part of the same work in a few days. The new appropriation of $75,000 by the General Government, with the available means at the disposal of the State board, will doubtless serve to ameliorate the condition of that great impediment to commerce; and, in time, it is hoped, for you to feel its effect on the business of the approaching season.

"I am, sir, very respectfully, your obedient servant,

"BRAXTON BRAGG,
"*Engineer to the Board.*"

"R. W. FORT, Esq.,
"*Secretary Board of Trade, Mobile.*"

I give the foregoing letter of General Bragg because of the facts it sets forth, and as evidence of the harmonious and successful co-operation of the United States engineer in charge and the State board.

J. H. S.

Annual report (1871–'72) *on the survey at mouth of Apalachicola River, Florida.*

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, July 31, 1872.

GENERAL: I have the honor to submit the following report for the year ending June 30, 1872, on the survey at the mouth of Apalachicola

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River, with a view to its improvement, under the act of Congress approved July 11, 1870.

This survey, at first under the immediate direction of Captain A. N. Damrell, Corps of Engineers, assisted by Mr. C. F. Trill, and subsequently, when Captain Damrell took charge of the district in my absence on sick leave, by Mr. Trill, was closed in the field on account of the want of more funds, in the early part of July; but being connected immediately with the survey of the Chattahoochee River, authorized by the act of Congress approved March 3, 1871, my report, submitting those of Captain Damrell and Mr. Trill, with the maps, finished in August, was deferred till the reports and maps of this latter survey could be at the same time forwarded, which was done on the 28th March.

As these reports constitute Ex. Doc. No. 241, House of Representatives, Forty-second Congress, second session, and are in sufficient detail, I think it unnecessary to say anything more on this head than to quote from my letter of submittal referred to above, as follows:

While these reports treat of the improvement of the channels of approach to Apalachicola, I would recommend only as feasible within reasonable limits of expenditure, as recommended by Captain Damrell, the dredging of a channel through the bar at the mouth of the river in the bay, from the 11-foot curve on the inside by the shortest line from deep water to deep water, which is also the line of deepest water in the natural channel, 100 feet wide, and 11 feet deep; the width to be afterward increased, if found proper from the success of the first cutting, to 150 or 200 feet, as may be found advisable.

A channel to allow vessels drawing 11 feet of water to pass up to the city, 100 feet wide, would require the excavation of about 200,000 cubic yards of sand and mud, which, at fifty cents per cubic yard, would cost about $100,000, $50,000 of which I recommend should be appropriated by Congress for early operations.

For a channel, same depth, and 200 feet wide, about 375,000 cubic yards of excavation, at 50 cents per cubic yard, would cost about $185,000.

Amount allotted from appropriation, act of July 11, 1870		$2,400 00
Amount received from United States Treasury on same account		$1,275 73
Amount transferred from survey of Tombigbee River		2,261 50
Total		3,537 23
Amount expended during the fiscal year ending June 30, 1871	$3,116 59	
Amount expended during the fiscal year ending June 30, 1872	420 64	
		3,537 23
Amount on hand and available July 1, 1872		
Amount remaining in United States Treasury uncalled for		$1,124 27
Amount required for the improvement of the harbor of Apalachicola		50,000 00

Respectfully submitted.

J. H. SIMPSON,
Colonel of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

Annual report (1871–'72) *on the survey of the Chattahoochee River, below Columbus, Georgia.*

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, July 31, 1872.

GENERAL: I have the honor to submit the following report for the year ended June 30, 1872, on the survey of the Chattahoochee River, with a view to its improvement, under the act of Congress approved March 3, 1871.

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The party making this survey was organized under the immediate direction of Mr. C. F. Trill, assisted by Mr. W. R. Warren as second assistant, and subsequently there was added to the party Mr. W. J. Squiers, as third assistant. The transit-line, on account of the difficulty of obtaining the requisite barge for the accommodation of the party and prosecution of the work, was not started at Columbus till the 19th October, and the survey closed at Eufaula, December 10; Mr. Squiers reporting his return at headquarters, Mobile, on the 14th December, but Mr. Trill, according to his statement, on account of his going to Apalachicola to put the boats and other United States property in care of local inspector of steamboats, not reaching Mobile till the 1st January. Mr. Trill's report and maps were submitted by me to the Chief of Engineers March 28, and as they constitute a portion of Ex. Doc. No. 241, House of Representatives, Forty-second Congress, second session, I deem it unnecessary to prolong this report any further than to extract the following from my report of March 28:

As connected with the improvement of the harbor and bay of Apalachicola, I also forward herewith the report of Mr. Trill on the survey of the Chattahoochee River.

Mr. Trill has grouped the obstructions into three classes, depending upon the extent to which it may be deemed expedient to improve the river at these points. The first class, at low water, actually stops navigation. The second class is about a foot better in depth of water, but yet needs improvement very much. The third class is not of much importance, but ought to be improved, if possible, to prevent changes for the worse in future.

His estimate for the first class throughout the whole river from Columbus to mouth at Apalachicola	$464,000
For the second class	327,000
For the third class	85,185

He recommends the first estimate, or $464,000, as being the only one which will comply with the requirements of unobstructed navigation, at all stages of the water, and warrant the efficacy and permanence of the improvement.

In addition, he estimates for completion of survey of Chattahoochee River	$5,000
Survey of Flint River, very much needed	8,000
Survey of Apalachicola River, on account of the difficult local circumstances, especially from Ricos Bluff, Florida, down	$10,000 to 12,000

In conclusion, I would recommend immediate appropriations as follows: $50,000 for the improvement of the harbor and bay of Apalachicola River; $50,000 for the improvement of the Chattahoochee River, below Columbus; $5,000 for the continuation of the survey of the Chattahoochee River, below Eufaula, to its junction with the Flint; $8,000 for the survey of the Flint River; and $8,000 for the survey of the Apalachicola River.

Amount allotted from appropriation of March 3, 1871		$4,500 00
Amount received from United States Treasury on same account		4,262 40
Amount available July 1, 1871		$3,922 90
Amount expended during the fiscal year ended June 30, 1872	$5,039 07	
Surplus being from funds transferred as follows:		
From Tombigbee River survey		9 08
From survey of Tampa Bay		4 97
From survey of Choctawhatchee River		382 80
From survey of Saint Mark's River		719 32
Total		5,039 07
Amount remaining in United States Treasury uncalled for		$237 60

Proportion of allotment of $15,000 under act of June 10, appropriating $150,000 for examinations and surveys of rivers, harbors, &c., as follows:

For examination and survey of the Apalachicola River from Chattahoochee, Florida, to Apalachicola	$3,750 00

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For examination and survey of the Chattahoochee River from Columbus, Georgia, to Chattahoochee, Florida $3,750 00
For examination and survey of the Flint River from Albany, Georgia, to Chattahoochee, Florida 3,750 00

Respectfully submitted.

J. H. SIMPSON,
Colonel Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

Annual report (1871–'72) *on the survey at the mouth of Saint Mark's River, from Spanish Hole to Saint Mark's, Florida.*

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, July, 1872.

GENERAL: I have the honor to submit the following report for the year ending June 30, 1872, on the survey of Saint Mark's River, Florida, from Spanish Hole to Saint Mark's, with a view to its improvement, under the act of Congress approved March 3, 1871.

The party making this survey was organized under the immediate direction of Mr. Joseph Burney, as first assistant, and Mr. Russell H. Curtis, as second assistant, in the latter part of June, and commenced operations in the field on the 6th day of July following. On the 14th October the field-work closed, the men were discharged, and the two assistant engineers repaired to headquarters, Mobile, to make up maps and report. These were completed on the 11th December, and were submitted by me to the Chief of Engineers, April 2. As the reports have been published by Congress, and constitute part of Ex. Doc. No. 63, Senate, Forty-second Congress, second session, I deem it unnecessary to repeat them in detail, except to quote as follows from my letter of April 2:

The difficulties in the way of navigation from the Gulf of Mexico to Saint Mark's, it will be perceived, are not so much the want of sufficient depth of water in the river, it being 9 feet, (except near the junction of the Wakulla River, where, for about 200 feet, the river requires deepening 18 inches through limestone rock,) as the obstructions caused by oyster-bars, which make the channel very crooked, especially at "Devil's Elbow" and "Duck Trap." The work, therefore, of improving the channel will be, principally, cutting through these oyster-bars, thus making the channel less tortuous.

The cost of thus improving the channel, making the proposed cuts 200 feet wide at bottom, with side-slopes of 2½ feet base to 1 foot vertical and 9 feet deep, Mr. Burney estimates at $40,866.10.

Mr. Burney, however, also states that he sees "no prospect at present of Saint Mark's rising in importance for many years to come." Under these circumstances he does not think it would be of any advantage to the State or district for Congress to grant an appropriation for the improvement of the river, the present channel being more than sufficient to accommodate the very limited business done.

In addition, he reports that it is in contemplation by the Jacksonville, Pensacola and Mobile Railroad Company to extend their road to deep water, at Spanish Hole, below which there is a good channel, allowing vessels to come up drawing 9 feet. This would greatly revive the trade of the port, and obviate the necessity of anything being done in the channel of the river between that point and Saint Mark's.

For the above reasons, I do not recommend any appropriation for the improvement of Saint Mark's River.

Amount allotted from appropriation of March 3, 1871 ..... $4,800 00
Amount available July 1, 1872 ..... 4,401 23

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Amount expended during the fiscal year ending June 30, 1872....	$3,681 91	
Transferred to survey of Chattahoochee River.....	719 82	
		$4,401 23
Amount available July 1, 1872.....		
Amount desired.....		

Respectfully submitted.

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

Annual report (1871–'72) *on the survey of Tampa Bay, at Tampa, Florida.*

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, July 8, 1872.

GENERAL: I have the honor to submit the following report, for the year ending June 30, 1872, on the survey of Tampa Bay, at Tampa, Florida, with a view to its improvement, under the act of Congress approved March 3, 1871.

The party making this survey was organized under the immediate charge of Gustave Jaenicke, assisted by Mr. D. M. Currie, at Apalachicola; arrived at Tampa on the 13th, and began work on the 17th July. The survey was completed on the 18th October, and the party discharged, except the assistant engineers, who proceeded to headquarters at Mobile, to prepare the maps and plans. The final report and maps of Mr. Jaenicke, completed on the 18th December, were submitted by me to the Chief of Engineers March 30, and as it constitutes a part of Ex. Doc. No. 252, House of Representatives, Forty-second Congress, second session, I deem it unnecessary to say anything farther than to quote from my letter above referred to, as follows:

Mr. Jaenicke submits three estimates:

1. For a straight channel, with a width at base of 200 feet and slope of 2.5 feet horizontal to 1 foot vertical, and a uniform depth of 12 feet mean low tide, estimated cost $502,121.90.

2. For deepening the present sailing-channel, which he prefers, 200 feet wide at base, 12 feet deep, and slope 2.5 to 1, estimated cost $549,621.80.

3. For deepening the present sailing channel, width at base 100 feet, slope 2.5 to 1, depth 12 feet, estimated cost $287,475.65.

In view of the magnitude of the cost of either of these projects, and the liability of the channel in either case to fill up, I would recommend as preferable (for private enterprise, however) the construction of a railroad from the city of Tampa to Passage Point. This point is only about nine miles from Tampa, affording a good site for an *entrepôt*, and what gives it especial value, vessels drawing 18 feet of water can approach it within a quarter of a mile. The railroad could be made and stocked for less than $20,000 per mile, or $180,000 for the whole distance; and as the city of Tampa at no distant day will be connected by rail with the Florida railroads to the north of it, I have no doubt that this extension of the road to Passage Point will naturally follow as a consequence.

For these reasons, and the present limited demand of commerce in this section, I do not recommend any appropriation by Congress for the improvement of the harbor of Tampa.

Amount allotted from appropriation of March 3d, 1871.....	$2,500 00
Amount available July 1, 1871.....	$2,164 50
Amount subsequently allotted and received.....	1,200 00
Total.....	3,364 50

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Amount expended during the fiscal year ending June 30, 1872	$3,359 53
Transferred to survey of Chattahoochee River	4 97
	$3,364 5
Amount available July 1, 1872	
Amount desired	

Respectfully submitted.

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

Annual report (1871–'72) *on the examination of Choctawhatchee River, Florida.*

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, July 31, 1872.

GENERAL: I have the honor to submit the following report for the year ending June 30, 1872, on the examination of Choctawhatchee River, Florida, with a view to its improvement under the act of Congress approved March 3, 1871.

This examination, which was all that was found to be necessary, was made under the immediate direction of my assistant, Mr. Joseph Burney, assisted by Mr. William S. Simpson, and was commenced by the organization of the party at Freeport, on Le Grand Bayou, of Choctawhatchee Bay, November 24. The examination was completed at Freeport, on the 22d December, when the men were discharged and Mr. Burney and his assistant repaired to headquarters, Mobile, to make up report and maps. These were completed during March, and April 6 were submitted by me to the Chief of Engineers. As these reports constitute a part of Ex. Doc. No. 63, Senate, Forty-second Congress, second session, I deem it unnecessary to state anything further than the following, which I extract from my report of April 6:

This report shows that vessels drawing less than 9 feet of water can pass eastward from Pensacola Bay, through Santa Rosa Sound, for a distance of twenty-six miles. Leaving the sound, they enter what is commonly called "the Narrows," ten miles in length, and from one-fourth to one-half mile wide, in which there is a depth of only from 4 to 5 feet water. The channel in these narrows is very difficult of navigation from the number of bars to be met, and on account of their shifting character is represented as not being susceptible of permanent improvement.

About four miles above the Narrows there is a narrow outlet to the Gulf, called "East Pass," having a depth of 5 feet of water on the bar, but which, on account of the violent action of the sea, is very seldom used.

All merchandise intended to ascend the Choctawhatchee River is obliged to be reshipped in barges, propelled by poles, at a small town called Freeport, five miles up Le Grand Bayou. This is a place, at the present time, of considerable importance, on account of having direct communication with New Orleans and Pensacola, by means of several schooners, from fifteen to thirty-five tons burden, besides occasional steamboats.

It is represented as unsuitable as a depot for transshipment of merchandise on account of its situation, causing the barges running on the river to be poled an unnecessary distance of sixteen miles. This is caused by all land suitable for a depot, at the mouth of the river, being held by the General Government for the purpose of obtaining timber for the Navy, although from all the information which could be obtained, the land is pronounced totally unfit for this purpose.

Neither the means nor the time before the winter-floods admitting of an accurate survey of the river, in accordance with my instructions, only such an examination of it from its mouth to Geneva, the present head of navigation, a distance of about one hundred and sixty miles, was made, as would be sufficient to predicate estimates for its improvement.

The result of this examination shows that there is available at all times between the mouth of the river and Geneva at least 8 feet of water, 3 feet more than can be carried through the Narrows, at the east end of Santa Rosa Sound, and that the obstructions

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consist principally of snags, sawyers, overhanging trees, and two wrecks of steamboats. Another source of difficulty arises from the, in some instances, tortuous direction of the channel. The improvements, therefore, proposed are the removal of the obstructions mentioned, and the straightening of the channel in places.

Mr. Burney submits three estimates. The first, amounting to $98,716.80, contemplates a thorough improvement of the river, but the present commerce, in his opinion, will not justify so large an appropriation by Congress.

The second, amounting to $52,291.20, contemplates not so exhaustive an improvement, but one which would be sufficient to meet all present and prospective requirements for many years to come.

The third estimate, amounting to $34,332, is for the removal of obstructions which make the navigation of the river both difficult and dangerous, even for the amount of trade done on it at the present time. This amount is about 10 per cent. of the value of the merchandise carried on the river during the past year, and it is believed this extent of improvement will be sufficient for at least five years to come.

As the report shows that the value of the available timber of commerce along the river is estimated from $50,400,000 to $144,000,000, depending upon the distance in which in can be profitably hauled, and the value of the business done during the past year was as much as $284,000, I respectfully recommend an appropriation by Congress of the least amount estimated by Mr. Burney for improving the river, and which the present amount of trade demands, viz: $34,332.

Amount allotted from appropriation of March 3, 1871		$3,000 00
Amount available July 1, 1871		$2,832 50
Amount expended during the fiscal year ending June 30, 1872	$2,449 70	
Transferred to survey of Chattahoochee River	382 80	
		2,832 50
Amount available July 1, 1872		
Amount required for the improvement of the Choctawhatchee River		34,332 00

Respectfully submitted,

J. H. SIMPSON,
Colonel of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

O 1.

IMPROVEMENT OF MOBILE HARBOR AND BAY.

MOBILE, *Alabama, February* 14, 1872.

GENERAL: The board of engineers constituted by the following order:

[Special Orders No. 4.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 6, 1872.

I. A board of engineers to consist of Colonel J. H. Simpson, Corps of Engineers; Lieutenant-Colonel Z. B. Tower, Corps of Engineers; Lieutenant-Colonel H. G. Wright, Corps of Engineers, will convene in Mobile, Alabama, on January 20, or as soon thereafter as practicable, to prepare a plan for the improvement of the harbor of Mobile. In connection therewith the board will examine the projects of the "board for the improvement of the river, harbor, and bay of Mobile, organized under authority of the State of Alabama," and report their views as to the probable effect of the work projected by that board upon the operations now being carried on by the United States for the improvement of Mobile Harbor, and upon those proposed by the plan they may submit for its improvement, and what modifications, if any, should be made in the projects of the State board.

Captain A. N. Damrell, Corps of Engineers, will act as recorder of the board.

* * * * * * *

By command of Brigadier-General A. A. Humphreys.

JNO. G. PARKE,
Major of Engineers.

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met at the city of Mobile, February 3, instant, the earliest day practicable, all the members, with the recorder, being present. They continued their sessions from day to day, examining maps of the river and bay of Mobile, and projected plans for their improvement, and such reports of boards and of officers of the Corps of Engineers as were at hand, visiting the localities of interest connected with the projected plans of improvement, viz: The inner harbor of Mobile, Choctaw Pass and Bar, the lines of channel obstructions, and Dog River Bar as far as the anchorage of the upper fleet, causing soundings to be made and specimens of the bottom to be procured whenever thought necessary; and further seeking information from other sources as to the condition of the bars and the depth of the water thereon, as well as in the channels, for the past forty years. On application to the "board of improvement of the river, harbor, and bay of Mobile, organized under authority of the State of Alabama," they were courteously furnished with their projected plans of improvement, with explanations of the same, both verbal and in writing, by their engineer, General Braxton Bragg; and they now have the honor to submit the following report as required by the foregoing order of the Chief of Engineers, giving their views as to the method of improvement of the channels of approach to the city of Mobile, "and as to the probable effect of the works projected by the board of improvement of the river, harbor, and bay of Mobile" upon the operations now in progress, and upon those still necessary to open the channel-way, as proposed by the General Government.

REPORT.

The inner harbor of Mobile is properly the anchorage in the Mobile River, extending northward from its mouth at Choctaw Bar. This river opens into the bay of Mobile, which extends a distance of about thirty miles to the south to Dauphin Island and Mobile Point. This bay or basin is, for the greater part, shoal; and it is this shoalness to so great an extent southward from the mouth of Mobile River that constitutes the difficulty in the way of obtaining and preserving the requisite depth of water on the line of approach to the city from the anchorage below.

At this date 21 feet depth at mean low water is maintained on the outer bar and in the "lower-fleet" roadstead, about twenty-five miles from Mobile, while 13-foot draught can ascend the bay to the "upper fleet," opposite Dog River, about nine miles distant from the mouth of Mobile River. The water shoals gradually from this 13-foot curve to Dog River Bar, where its least depth in the channel, three miles distant from Choctaw Bar, is but 9 feet, deepening again above to 10 feet till the lower line of obstructions is reached. From this point to the upper obstructions the direct channel and that of Spanish River show a least depth of 12 feet, the latter river, however, having a greater depth through the larger portion of its length, while the former shoaled at Choctaw Point Bar to 7½ feet at mean low water before the excavations now in progress were commenced. The want of hydrographic charts of Mobile Bay (none prior to 1852 being before this board) prevents us from ascertaining the earlier condition of the channels of approach to the city and of the exterior bars farther than can be derived from the testimony of Captain John Grant, a well-known and intelligent citizen of this place, of large personal experience, having been engaged on works of harbor and channel improvements for the past forty-five years, and residing in this vicinity for the greater part of that period. By his testimony the outer or Dog River Bar does not vary essentially, having maintained

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from 8 to 9 feet depth of water over its shoalest part since his arrival at this place in 1826, while Choctaw Bar gradually shoals from year to year, but very slowly. The greatest depth of water on this bar being but 5½ feet in 1828–'29, it was then dredged to give a channel-way of 8 feet at mean low tide, which was again deepened by the same process in 1838–'39 to 10 feet; but having been left without further care for a period of twenty-one years, was found, in 1870, to have but 7½ feet depth. Southerly and southeast winds, it is believed, create a wash in Garrow's Bend that moves the sands of that shore around Choctaw Point, causing the shoaling of the waters southeasterly from that point and on Choctaw Bar, and gradually filling Choctaw Pass. Some forty samples of the bottom soil were procured from the pass and bar, and from various portions on the shoals to the west, and from Garrow's Bend, which seemed to confirm the opinion that the shoaling process, both in the pass and on the bar, is due, at least in part, to the accumulations drifted from the bend, and that jettees might be advantageously placed along that shore to prevent this drift. The river, doubtless, deposits some of its silt, as the waters at its mouth widen; but if the sand-drift from the bend can be effectually checked, the shoaling process on the bar will probably be much less rapid than at present. Our opinion, in this respect, differs from that of the board of 1860.

Having thus briefly described the channel of approach from the anchorage of the bay to the inner harbor of Mobile, and the two obstructing bars to this passage, and pointed out (what is apparent from an examination of the chart of Mobile Bay) that the difficulty in the way of its improvement arises from its being merged or lost in the waters of a wide shoal bay extending southward about twenty-five miles before gaining a depth of 18 feet, this board are compelled to admit that the problem before them does not promise an easy or entirely satisfactory solution, or, at least, one that will give, in a strict sense, a permanent improvement.

Such a channel or passage-way can only be deepened by the scouring-process, or by dredging, or by both combined. The first would require that the river currents, to effect this end, should be confined within narrow limits by dikes or jettees, which, carried so far into the bay, would be very costly, and if made with timber, the only material available within reasonable limits of expenditure would decay above the low-water line, and in its southern portion would be rapidly destroyed by the sea-worm. Moreover, the river-silt, passing through this channel, would rapidly form a bar at its mouth, necessitating the prolongation of the inclosing dikes, or the dredging of the bar at short intervals, either of which operations would require frequent outlays in addition to the original cost.

The board see such objections to this method of improving the channel of approach to the city of Mobile from the upper anchorage that they have not deemed it necessary to make any plans or estimates of its cost.

The other method of improving this channel by dredging will also be very costly, and it cannot be hoped that the results will be entirely permanent; in other words, that the depth attained will be preserved without additional dredging from time to time. Of the two methods, the board, however, prefer the latter, believing it the more likely to procure, if not a strictly satisfactory channel, at least a better one than can be obtained at the same cost by any other means that have been suggested. The operations necessary to dredge this channel to a suitable depth will probably involve an outlay of $630,000 in addition to that

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already granted, and small appropriations from time to time to preserve the depth of water attained on the completion of the work.

Admitting the above conclusion of the board, that the dredging-process is the preferable method of improving the channel of approach to the city, two projects present themselves for our consideration: the first, to dredge Choctaw Bar to a depth of 9 feet at mean low water, the present depth on Dog River Bar, which would permit the passage of vessels of 11-foot draught at high tide, and which could be effected and maintained without great cost; and the second, to dredge a suitable channel, 13 feet deep, over both bars for a length of nine miles from the inner harbor of Mobile, giving a draught of 15 feet at high water to the upper-fleet anchorage, and during the prevalence of southerly winds one foot more. The board are of opinion that the commercial interests of the city and State will justify the large expenditures as estimated to secure the deeper or 13-foot channel. The problem for solution, in this bay, is similar to that in Patapsco Bay for the improvement of the channel of approach to the harbor of Baltimore. If the method by dredging is a success there, as it is believed to be, it will probably be so here, as the bay of Mobile is not more exposed to action of storm-waves than the open reach of Patapsco Bay.

As to the direction of this artificial channel, the board concur with that of 1860, and with both of the engineer officers recently in charge of the Mobile Harbor improvements, that the line of deepest water should be followed as it has existed for the past fifty years, since this line must now be regarded as a resultant of a fixed regimen of the different rivers uniting to produce this channel. The curve at the upper obstructions should be made as gentle as possible, and the opening or width of channel in that part somewhat increased, to admit the ready passage of the largest class of vessels that may enter the inner harbor of Mobile. It is recommended that this excavation be restricted to a width of 200 feet throughout its length, at least until its comparative permanency can be tested or established.

The board give it as their opinion that this excavation should be made as rapidly as possible, for if portions only are dredged, and left in an uneven or lumpy condition, such portions will fill to the level of the projections; and, besides, there will not be a clear water-way for the ready movement of the bottom current until each bar is cut entirely through and finished to an even surface. If, on the other hand, this dredging should proceed slowly and at intervals, it will be but a partial success. No good results can be predicted, except from a rapid and thorough execution of the work. The sketch accompanying this report shows the channel in red lines, as proposed by the engineer officer of this station, with the slight modifications at the upper bend already alluded to, and now submitted by this board to the Chief of Engineers, for his consideration.

It should be here noticed that the State board of harbor improvement, under the direction of its engineer, General Braxton Bragg, have removed the upper obstructions across the channel of the Mobile River, immediately beyond the Choctaw Bar, to a width of 600 feet. The remaining portion of this obstruction westward is not thought to be prejudicial to the channel. In similar manner, the gap in the lower obstruction has been opened to a width of 600 feet. Where the channel-way of Spanish River crosses the upper obstructions the gap is now about 200 feet wide. It is apparent that the width of this channel, and the great body of water—that of Spanish and Tensaw Rivers combined—passing in this direction, require a wider opening through this line of obstruc-

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tions—an interval of at least 600 feet; otherwise the flow, in part, will crowd eastward, and not continue in its proper direction, to unite with the current of Mobile River, through the outer channel over Dog River Bar. It would be well, for a year or more, to observe closely as to the effect of the remaining portions of these obstructions, with a view to ascertain if they are in any manner prejudicial or beneficial to the channel-way as it now exists beyond the debouches of the several rivers into Mobile Bay; and further, as to expediency of extending the upper obstructions westward to the shore at Choctaw Point.

The board having given their opinion as to the method of improvement which promises a better channel of entrance to the river-harbor of Mobile, in compliance with their instructions, will now present their views as to the probable effect of the works projected by the "board for the improvement of the river, harbor, and bay of Mobile," organized by the State of Alabama, upon the operations now in progress on the part of the United States to deepen the channel of approach to the city. These projected works are explained in accompanying papers submitted by General Bragg to this board, marked A, in the appendix. Quoting from this manuscript, the first of these projected works now in process of construction is "a structure of piles and filling across the head of Pinto or Middle Pass, intended to close the same, and force the water now flowing through that pass into the main channel by Choctaw Point." There will be some increase to the volume of water flowing out of the mouth of Mobile River by shutting up this pass, producing, probably, some scouring effects below on the river-banks or bottom, the heavier or sandy portions of which, if this increased flow of water be rapid enough to move sand, will be redeposited as soon as the slackwater will permit, while the finer portions will be carried farther out into the bay, and mostly dispersed in its shallow waters on Dog River Bar and beyond. And here it may be well to observe that any scouring-process that moves material from the banks or bottom of a river near its mouth, only transfers it into the bay or sea beyond, to form a bar there, if the water be shoal. Any large increase in the flow of Mobile River will probably move Choctaw Bar farther toward the bay, and result in injury to the works now in progress. This bar is nearly all sand, and no current in the upper part of the bay is rapid enough to disperse it. The aim of all works of improvement at this locality should be to avoid such operations as lead to the movement of sand to the mouth of the river. In fact, the deepening of Mobile River by the scouring-process seems incompatible with the preservation of the channel through Choctaw Bar, as now in progress of execution. It is questionable, however, if this dike will create any such serious disturbance in the river; and this board do not, therefore, make a point of objecting to its construction any further than noticing its possible detriment to the excavations on the bar below. If these excavations had not been commenced, the board would not have thought it necessary to have presented any remarks as to the closing of Pinto Pass.

2d. "A similar work along and in prolongation of Pinto Island at its southern end, to 6 feet of water, intended to close the opening through that marshy bank, keep the water concentrated in the channel, and prevent a constant washing by southeast winds upon the lower city front, and by which it is believed much sedimentary matter is driven into the stream and carried down to be redeposited on reaching slackwater." No objection is made by the board to this construction.

3d. "A similar work just below the swamp at Choctaw Point, to check the abrasion long continued on that part of the city front, and

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incidentally to intercept a drift, believed to aid in the formation of Choctaw Bar. Originally projected to a length of 4,000 feet, this work is now restricted to 1,500 feet at the shore end." This jettee is now being constructed, and two other short jettees are also to be constructed under same authority, to the westward of the present jettee, if found advisable. The board are of the opinion that the jettee now being constructed will prove beneficial in preventing sand from being drifted along by the shore current upon Choctaw Bar and Pass. They would, however, have recommended the construction of the several short jettees, beginning at a point farther to the westward on this shore, to accomplish the same purpose, if the present jettee had not been commenced by General Bragg.

4th. "The removal of two large wrecks opposite the city, which not only impede navigation, but serve to accumulate deposits and cause the formation of bars." These sunken vessels disturb the regimen of the river, and their removal must be beneficial to the preservation of its normal condition, as well as to freedom of movement of shipping in this inner harbor. The manuscript continues as follows:

These include all the works now in progress under this board. At the time they were projected, it was also contemplated to remove a heavy structure on the west side of Pinto Island, including large deposits above and below it, which had narrowed the channel, to the serious injury of navigation, and tended to force the water through Pinto Pass. This was deemed the more necessary as a serious encroachment has been made on the opposite side of the river, by the construction of a railroad-wharf far into the stream. This work was abandoned in deference to opposing views from those engaged in the removal of Choctaw Bar.

The removal of the heavy structure, which seems to be a line of piles serving as a boom for logs, would probably be beneficial as preventing sedimentary deposits along the west shore of Pinto Island. The objection urged by General Simpson, as stated by him to this board, was made as to the manner of removing the "large deposits above and below" the pile-structure, or boom, including a large portion of Pinto Island, it being understood by him that the removal in question was to be done by excavation so far only as it was necessary to effect the purpose, and the rest by the scouring-process, which would carry large quantities of silt, sand, roots, logs, &c., into the channel then in process of excavation through the bar below. Excavation on the Pinto Island side of the channel, to increase its width and depth, made by dredging, would not interfere with the present operations on the part of the United States. And the board would here give their opinion that the deepening of the water about the wharves or slips of the city front, or in shoal places of the channel, or on the opposite shores, ought to be done by dredging, and not by constructions that induce scouring at these points, as the material thus washed away by currents must be transported to be redeposited where the river opens into the bay.

General Bragg goes on further to state that—

Upon the completion of the above-named works, it is contemplated to reduce the width and depth of Spanish River at its head, and thus force a portion of its present current through the main stream, but not to an extent impeding the passage by any vessel which can now reach that point. It is believed these several additions to the main stream will be ample to restore to our use our greatly impaired water-front, and give a depth of water thereat sufficient for all present purposes. Should this anticipation not be realized, similar work may be necessary at the head of Tensaw.

This proposition to shut up the head of Spanish River, leaving only a passage for vessels, if effectual in largely increasing the flow of water in Mobile River, may, and probably will, scour away sedimentary de-

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posits along the wharf-front, or increase the depth of water of the river, washing the bottom to a greater depth than is needed, for it is well established that a large increase in the flow of a river will seriously disturb its regimen; but precisely in what manner, it is difficult to be foreseen. At any rate, most of the material removed, whether by erosion of the banks, or by scouring the bottom, will be swept down and redeposited where the widening of the waters checks their velocity sufficiently to permit such deposit. It does not follow as a sequence of this increase that its efforts will be directed only to those points which require deepening. In the present case the abrasion may take place at one or many points along the Mobile River, above the city, where such disturbance cannot be otherwise than detrimental, as well as in its front. To the extent, therefore, that this partial closing of the head of Spanish River may increase the cross-section of Mobile River, whether above the city, where nothing is to be gained by widening or deepening it, or along the city front, the wash carried below will doubtless be of serious injury to the channel proposed on the part of the General Government. Besides, so great a change in the regimen of Mobile River will doubtless produce a change in the regimen of the channel beyond Choctaw Pass, probably giving a new direction to the flow of the combined waters below that pass. It is impossible to anticipate the alterations that would result from so important a change as the throwing of the greater part of the waters of Spanish River into Mobile River. Should the head of Tensaw River, in addition to that of Spanish River, be similarly closed by obstructions reaching almost across the water-way, the disturbance of the regimen of Mobile River will be farther increased, and the injurious results to the works below proposed by the United States proportionally augmented. If we supposed both of these rivers closed, or nearly so, the bar at the mouth of Mobile River would probably be thrown farther southward, and the direction of this single current would doubtless be different from that which now results from the combination of the streams of Spanish and Mobile Rivers, between the two lines of obstructions. It matters little where this bar is formed, whether at Choctaw Pass or farther southward, it will probably require dredging to give passage to vessels of 13-foot draught at mean low water, and whatever may be the result of the changed regimen of Mobile River, by the greater flow of water between its banks, there still will remain the long reach of shallow water of the bay, beyond the bar southward, as far as the 13-foot curve, (about seven miles,) to be dredged as proposed in this report, to get the required water-way. It is to be remembered that the bar at the mouth of Mobile River, only 3,200 feet across, is but a small obstacle to the passage of vessels to the inner harbor of Mobile. Below the lower line of obstructions nearly the same amount of water flows now, viz, the combined streams of Mobile and Spanish Rivers, as would result from joining these streams at some higher point.

It would seem that General Bragg, in his arguments in favor of enlarging the water-flow of Mobile River, has lost sight of this important feature of the bay, in his anxiety to work immediate benefit to the wharf-front and anchorage of the city. For the reasons thus set forth, this board are of opinion that the partial closing of both or either of the two named rivers, as proposed by General Bragg, would effect serious detriment to the operations now in progress by the General Government, and to those proposed in continuance of plans of improvement which have received the sanction of the board of 1860, of the successive en-

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gineer officers on this station since that date, and of the Chief of Engineers of the United States Army.

General Bragg's manuscript goes on further to state that—

It is also proposed to continue filling the slips between wharves along the city front, and eventually to build a solid bulk-head along the whole, as indicated on Plan No. 3, cutting off such wharves as project beyond the new line, (red,) and extending all others to it.

The sketch accompanying this report, and the ordinance of the city of Mobile, marked B, in the appendix, exhibit this new line of water-front as established by the city authorities. It seems that some of the wharves are open pile constructions, and others are solidly filled in with earth; and that in the upper part of the city the slips are more or less shoaled, so as to admit only the smaller class of vessels. The city sewers pouring sandy and other material into these slips, and the eddies formed by the wharves and by the shipping lying in these slips, are doubtless the causes of the sedimentary deposits that have rendered these wharves almost useless. To remedy this defect of construction it is proposed to eventually fill up these slips, and build a continuous bulk-head along the line established by the city ordinance above referred to, and it is expected that this change will give a sufficient depth of water along the city front for the largest class of vessels that can enter the inner harbor.

It would seem, in this connection, that some method of sewerage might be adopted to prevent the large quantities of sand carried through the sewers from being thrown into the river, and thus eventually finding their way to their bar at its mouth. The board notice this defect of the city sewerage, not in the spirit of criticism, but rather with the desire that such cause of detriment to the improvements proposed may be avoided if possible. General Bragg, in conversation with the board, alluded to this defect in the city sewerage, for which no remedy has, as yet, been proposed. The line, as marked out between Theater and Elmira streets, encroaches quite into the river, in that part which is opposite to Pinto Island, where the harbor is narrowest. This portion of the line was doubtless determined upon while the State board of improvement intended the removal of a large part of Pinto Island by dredging and scouring. If no portion of this island is dredged away, this board are of the opinion that the line of wharf-front opposite would better be retired somewhat; perhaps following a curve to turn the water flowing down, so that it may impinge more obliquely on the shore below, and to secure a greater width of river and harbor in this reach. South of Elmira street the proposed line is to take a direction south 10° east. The city ordinance cited does not give the extent of this line in the prescribed direction, but prohibits wharves being built outside the front thus limited. It is evident that the bulk-head should not be continued in that direction any further than necessary to meet the curve of the shore, as its contour line below Elmira street ought to be preserved in order to maintain the direction of the currents as they now exist, the wharf-line thence corresponding with the shore-line.

The board have thus briefly alluded to this new wharf-front as one of the projects, not yet commenced, that might, to some extent, affect the general regimen of the river, and cause some changes in the channels being excavated below. It is thought, however, that with care to avoid what seem to be defects of this plan, as above pointed out, the improvement contemplated may prove beneficial to the city, without causing disturbance to the operations on the part of the United States, from

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which it is hoped a great benefit will accrue to the commercial interests of the city of Mobile.

Respectfully submitted.

J. H. SIMPSON,
Colonel Engineers and Brevet Brigadier-General, U. S. A.
Z. B. TOWER,
Lieutenant-Colonel Engineers, Brevet Major General, U. S. A.
H. G. WRIGHT,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

APPENDIX A.

OFFICE OF THE BOARD FOR THE IMPROVEMENT OF
THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, February 9, 1872.

SIR: In compliance with a resolution of the board for the improvement of the river, harbor, and bay of Mobile, I have the honor, in response to your request of the 7th instant, to lay before you the several maps of Mobile River, prepared in this office, including—

1. The bifurcation of the river at the head of Tensaw.
2. The same at the head of Spanish River.
3. The city front and bifurcation of the river at Pinto or Middle Pass.
4. The bay-shore from Choctaw Point to the southern limits of the city.

The only works now in progress, made under the direction of this board, will be found located in pencil on these maps.

1. A structure of piles and filling across the head of Pinto or Middle Pass, intended to close the same and force the water now flowing through that pass in the main channel by Choctaw Point.

2. A similar work along and in prolongation of Pinto Island, at its southern end, to 6 feet water, intended to close the openings through that marshy bank, keep the water concentrated in the channel, and prevent a constant washing by southeast winds upon the lower city front, and by which it is believed much sedimentary matter is driven into the stream and carried down to be redeposited on reaching slack-water.

3. Similar work just below the swamp at Choctaw Point, to check the abrasion long continued on that part of the city front, and, incidentally, to intercept a drift believed to aid in the formation of Choctaw Bar. Originally projected to a length of 4,000 feet, this work is now restricted to 1,500 feet at the shore end.

4. The removal of two large wrecks opposite the city, which not only impede navigation, but serve to accumulate deposits and cause the formation of bars.

These include all the works now in progress under this board. At the time they were projected, it was also contemplated to remove a heavy structure on the west side of Pinto Island, including large deposits above and below it, which had narrowed the channel, to the serious injury of navigation, and tended to force the water through Pinto Pass. This was deemed the more necessary as a serious encroachment had been made on the opposite side of the river by the construction of a railroad-wharf far into the stream. This work was abandoned in deference to the opposing views from those engaged in the removal of Choctaw Bar.

Upon the completion of the above-named works it is contemplated to reduce the width and depth of Spanish River at its head, and thus force a portion of its present current through the main stream, but not to an extent impeding its passage by any vessel which can now reach that point. It is believed these several additions to the main stream will be ample to restore to use our greatly impaired wharf-front, and give a depth of water sufficient for all present purposes. Should this anticipation not be realized, similar work may be necessary at the head of Tensaw.

It is also proposed to continue filling the slips between wharves along the city front, and eventually to build a solid bulk-head along the whole, as indicated on Plan No. 3, cutting off such wharves as project beyond the new line, (red,) and extending all others to it.

Two other small jettees, below Choctaw Point, are contemplated, dependent, however, on the effect produced by the first, now under construction.

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The board has not adopted, nor even entered upon the discussion of any general plan of work in the bay, deeming it best to await the result of present operations by the General Government.

Copies of reports made by the engineer to this board are herewith inclosed, and it will afford him pleasure to comply with any request for further information or explanation on the points above indicated, or to aid personally in any manner to further the general object we must all have in view.

I am, sir, very respectfully, your obedient servant,

BRAXTON BRAGG,
Engineer to the Board.

General J. H. SIMPSON,
United States Engineers, President of Board, &c., &c., Mobile.

OFFICE OF THE BOARD FOR THE IMPROVEMENT OF
RIVER, HARBOR, AND BAY OF MOBILE.
Mobile, January 2, 1872.

To the president and members of the board for the improvement of the river, harbor, and bay of Mobile:

GENTLEMEN: At the close of the year it seems proper that a statement of the progress made since your organization in February last in prosecuting the important work confided to you by the State shall be submitted, and that a general outline of what is proposed for the future be placed upon your record.

All legal impediments having been removed, the board was organized for business on February 27, 1871, and conferred upon me the appointment of engineer, which was promptly accepted. The United States Government, with an appropriation of $50,000, was then engaged, under a contract with Captain John Grant, commencing in September, 1870, in dredging a channel through Choctaw Bar.

Preliminary to any action, and with a view to harmonize the work of this board, as far as practicable, with that of the Federal Government, the engineer in charge of the latter was requested to inform me of the plan on which he was operating, and the progress he had made in its execution. He promptly replied, furnishing a copy of his report of the 26th December, 1870, in which he details the plan proposed by a board of engineers in February, 1860, for deepening the channel through Choctaw Pass Bar and Dog River Bar by dredging, to which he gave his indorsement and approval. In addition to this, he proposed the removal, in part, of two lines of obstructions placed across the channel between these two bars, after the date of the visit and report of that board.

The estimated cost of the work necessary to test this plan, viz, dredging a channel 13 feet deep and 200 feet wide, including $45,000 for removing the obstructions, was $774,315.52. If successful, more than 50 per cent. additional would be necessary to complete the work. (See General Simpson's report, December 26, 1870.)

Expressing his satisfaction at your desire to harmonize and co-operate with him in accomplishing the end in view, the United States engineer suggested a division of this work on which he was engaged, and requested that you undertake the removal of—1st, the upper line of obstructions; 2d, the lower line of obstructions; and, 3d, to excavate the Dog River Bar Channel.

At my suggestion you promptly authorized me to enter on the first two items of this work, and responsible parties were soon actively engaged under contracts with this office, which were faithfully executed, and the results, entirely satisfactory, were made known to the United States engineer.

My attention was early called by prominent citizens and business men of the city, including some members of your board, to the condition of the city front, and of the river, above any work projected by the United States Government. Important changes had taken place since the visit of the engineer board, in 1860, and others were in progress, which, if not checked, would result, it was feared, in a final diversion of the river from the entire city front. Such information as could be obtained from all citizens, from pilots, and from old city maps, aided by a cursory examination, satisfied me that their apprehensions were not unfounded. It was discovered that wharf-owners, and other property-holders, on the river-bank along the whole city front, had been permitted, in contravention of authority, to build into the river beyond the former deep-water line, which was about where Water street now runs, until the channel or waterway had been permanently contracted at least 600 feet; and that the same kind of work was still progressing at an alarming rate. Had there been no other mouth to the river, or outlet for the water, an erosion of the other bank, if not similarly protected, or a deepening of the channel, would have been the necessary result. Two other natural outlets, Spanish River and Middle or Pinto Pass, however, presented an easier solution, and by them the water driven from the city front was conveyed to the bay.

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The depth of water at many of the wharves was found to have decreased so as to render them useless even for the larger class of boats engaged in river navigation. Here was a condition of affairs the continuance of which rendered large expenditures in the lower bay but a prodigal waste of means, for no result could be made available.

Before forming more than a general conclusion on so important a subject, involving a heavy expenditure, I applied for and obtained your consent to make a careful instrumental survey of the river from Choctaw Point to the head of the Tensaw. For this purpose instruments had to be procured and assistants employed. Some time during the progress of the work, about the 1st May last, the United States engineer in charge here, with whom the foregoing correspondence and understanding were had, left on "leave of absence."

During this same period proper steps were taken to secure the use of necessary dredging-machinery, to be applied at such time as your means might allow and your judgment direct. Before I was made aware of the completion of the surveys which were promised me, and which were necessary as a preliminary to the dredging-operation on Dog River Bar, my attention was called to an advertisement asking for proposals at the United States engineer office for the execution of that work, a new appropriation of $50,000 having been made by Congress. As I had satisfied my mind by this time that there was a large amount of work outside of that contemplated by the plan of dredging, which was more necessary and of less doubtful effect, no objection was made to this change of programme. Indeed, I was fully convinced, after a more thorough investigation of the subject, that this experiment was too costly for you, involving over $1,000,000, if it be carried out in its full extent, however advisable its partial execution might be as a temporary mitigation of the evil, or as an adjunct to other and more enduring works. For these and other obvious reasons, and in the absence of the chief officer, with whom the aforementioned correspondence was had, the matter was passed over without comment from this office.

The survey of the city front showed such serious encroachments upon the channel of the river by structures built in direct violation of law, and yet so difficult of removal, that a new line of wharf-front was deemed advisable. In the establishment of this new line a very serious difficulty was encountered. By a city ordinance, the New Orleans Railroad Company was authorized to extend its wharves and depots between Government and Theatre streets, to a line in the river varying from 60 to 100 feet beyond the former wharf-line. This ordinance had been repealed by subsequent action, but the company claimed a vested right, and was rapidly progressing in the construction of their works. Located at the point where the current was deflected into Middle or Pinto Pass by former structures, this work became much more serious and damaging than any which had preceded it. As soon as all the facts could be ascertained, the matter was laid before you and a committee was appointed to confer with the railroad company. After considerable delay, and much opposition from the company, a compromise was agreed on, by which the railroad yielded about two-thirds of its claim on condition that the work already done should not be removed. This was accepted by you as the best and least expensive solution of a complicated difficulty.

The new wharf-line suggested by the city engineer and myself, on the completion of this survey, was recommended by you to the city government, and promptly adopted. If adhered to, and the penalties for building over it are rigidly enforced, many of the difficulties heretofore encountered in the city front will be permanently removed.

The investigation of this whole subject of the wharf-front developed facts well worth the attention of our city fathers and property-holders. These encroachments now fill with solid structures one-third of the original river-channel, and the water has been driven therefrom into the eastern outlets. Owing to the existence of these lateral outlets, the depth of water in the remaining two-thirds of the main river, instead of having been deepened by the process of scouring, has, in reality, shoaled to an alarming extent. An inspection of the soundings along the old wharf-line for two-thirds its extent shows a depth varying from 5 to 9 feet only, *insufficient to accommodate the class of vessels now reaching our almost deserted port.* It is but a short-sighted policy on the part of property-holders which slightly increases the area by destroying the value of the whole. But the great surprise is that this process should have continued, without objection, under the eyes of those employed to prevent it. Their attention seems to have been absorbed, however, to the exclusion of everything else, by a gigantic scheme of perpetually digging out a perpetually re-forming bottom to the bay.

The survey was continued to include the outlets to Tensaw, Spanish River, and Middle or Pinto Pass, with cross-sections, to show the relative capacity of each. The results were briefly stated in my report of the 25th August, 1871, as follows:

"The conclusions reached in my former report, as to the effect produced in the main channel of the river by the long-continued encroachments, have been fully confirmed by subsequent data, and by further study of the plans and cross-sections prepared from the surveys.

"Above the head of Spanish River, the Mobile River has an average width of fully 1,200 feet, with a cross-section of 22,250 feet, and an ample channel-way of 30 feet

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depth. The same distance below the head of Spanish River the width of Mobile River is found not to exceed 1,000 feet, with an average cross-section of only 13,000 feet, and a channel depth of only 15 feet. Examining further, we find this loss fully accounted for by the cross-sections of Spanish River, showing 10,000 square feet and a channel-way 20 feet deep.

"Following the Mobile River down, no material change is noticed until we reach the wharves of the city, except some 1,500 square feet added from the Chickasabogue and Three-Mile Creek. From the upper to the lower limits of the city, serious encroachments have been made, as reported in my last. The tendency has been to force the water from the city front through Pinto Pass, and this tendency has been aided by the very serious encroachments on both sides of the river below the head of Pinto Island. As the result, we find a width of only 640 feet for the main river, and a cross-section of only 7,500 square feet, just one-third of the water-way found above Spanish River. The natural effect is apparent, just below, in the gradual growth of the marsh-flats on both sides of the river near the end of Pinto Island and Choctaw Point. A continuation of these causes must soon close this channel and ruin all wharf-property below Theatre street, and eventually up to Government street. (All above Government street has already been rendered useless for sea-going vessels.)

"There is but one remedy for this unfortunate condition, produced by our own imprudence. Further encroachments must be stopped, the way must be opened, and the water must be brought back to the main channel. To open the way only, would leave it to be closed again by the same process, and we should have an increasing, never-ending demand for dredging. Where the river is not obstructed above the city, nature preserves its own channel, with an ample width and depth for all purposes, and it will do so in front of the city and below it, if we only permit it to exercise its own unerring laws.

In addition to the work of opening and controlling the water-way of the river, I have projected and advised the construction of a jettee below Choctaw Point, to prevent the further abrasion of the western shore of the bay, and drifting of the sand on the Choctaw Bar, by which the labor of dredging at that point is much increased, and the practical results, at times, greatly reduced. This work will also tend to prevent the spread of the river-water as it enters the head of the bay, and thereby aid in keeping open the channel whenever the dredging shall have been completed.

"Recalling your attention to my report on this subject, dated June 12 last, I beg to submit the accompanying plans and estimates for the work necessary to carry out the suggestions then and now made, for restoring and controlling the channel-way of the river below the head of Point Island, and bringing back to its proper outlets so much of the water now diverted through eastern channels as may be necessary to accomplish this essential object."

The members of this board personally cognizant of the perilous condition of the city's interest, and no longer doubtful of the causes, unanimously adopted the suggestions, and ordered the execution of works deemed essential to preserve the river-front from conversion into a stagnant and pestilent cess-pool and marsh.

The removal of the obstructions, and the surveys and other necessary work incident thereto, had brought us to the month of September, but no time had been lost except what was due to the change of programme in the office of the United States engineer, and even that has resulted in a pecuniary saving of no small amount.

Before any contracts were let for the execution of the several works projected, I was informed that one, that of cutting away a portion of Pinto Island, to restore the natural width of the river, met with opposition in the office of the United States engineer. In the prolonged absence of the chief, with whom I could confer, the board, at my request, decided not to proceed with the execution of that work. A part of the others were contracted for on favorable terms, and are now being constructed. More will be submitted to you as soon as the progress is such with those under contract as will justify the increased volume of water to be brought from above.

All of the work contracted for has been taken at low prices. That of removing the obstructions, for instance, was successfully completed at a cost not exceeding three-fifths of the United States estimates, and all other expenditures have been restricted to the narrowest limits. Nothing has been lost.

It is proposed for the present to continue the work of concentrating in front of the city so much of the water of the Mobile River as may be necessary to give sufficient width and depth for the accommodation of the sea-going vessels drawing 15 feet. There is but one way in which this can be done—forcing the water back from the eastern outlets into the main channel from which it has been driven. It will appear strange for me to assert that large rivers give deep, and small ones shallow water, yet this point has long been in dispute in regard to your river and harbor, and the result has been the expenditure of vast amounts without the slightest benefits ever having been apparent. Mobile River, above the Tensaw, and even above Spanish River, has ample width and depth for the accommodation of any vessel which can enter the lower bay. But so much water is taken off by these eastern mouths—as they may be appro-

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priately called—that the main river, seriously obstructed below, and again divided at Middle Pass, has become almost useless, and is in great danger of being lost.

But for the serious opposition which this plain proposition has recently met, I should feel that I was taxing your patience by any further discussion. A few authorities will be adduced, however, in support of so plain a truism.

D. H. Mahan, "professor of military and civil engineering, United States Military Academy," for more than forty years, and under whom all the one hundred and fourteen officers now in the United States Engineer Corps graduated, including the two at this station, has published a valuable work on civil engineering, now used as a text-book at the Military Academy, in which, under the head of "rivers," he used the following plain language:

"If the river separates into several channels at the bar, dams should be built across all except the main channel, so that, by throwing the whole of the water into it, the effects of the current may be greater upon the bed."

The city of Saint Louis, some twenty years ago, was threatened with the same disaster to her front which has now befallen Mobile. By imprudently obstructing the river, the water was driven through an eastern channel, on the Illinois side. I have been unable to procure an official account of the work which was done by the United States Engineer Department to counteract this, but the following, from a report in the New Orleans Academy of Sciences, dated 1868, answers every purpose: "The plan of jettees has never been thoroughly tested at the mouth of the Mississippi, but the facility with which its currents may be controlled was illustrated in 1850, in the upper portion of the river, opposite Saint Louis, where a bar was found forming below, and extending upward in front of the city, throwing the channel on the east side of Bloody Island, and threatening to leave Saint Louis inland.* A dam of loose stones was constructed diagonally from Bloody Island to the Illinois shore, three-quarters of a mile in length, 50 feet at the base, diminishing to 30 feet, which was found effectual, turning the current into its former channel on the west side of the river, and removing the island (Duncan's) which had already formed, together with its accumulated trees, and rendered the lower landing at Saint Louis accessible to the steamboats which had formerly been driven from there by this accumulation." This work was done on no less authority than Captain R. E. Lee, United States Engineers, who was also a pupil of the venerable and eminent Professor D. H. Mahan.

In the year 1837 the city of Charleston was found in precisely a similar condition. A low marshy flat in front of the city, called Hog Island, had a channel to the east of it, through which the water of the river obstructed, as with us, was being driven. The United States engineer officer ordered to survey and report on the subject, recommended the closing of this channel. The Chief of the United States Engineers, General J. G. Totten, approved this recommendation, and in his annual report, dated Washington, November 10, 1846, says, under the head of roads and harbors:

"Closing Hog Island Channel, Charleston Harbor, South Carolina.—In 1839 this Department recommended the closing of this channel as a means likely to prevent further accumulation of mud in the front part of the city of Charleston, and, indeed, not unlikely to cause the removal of mud already deposited. * * * I recommend that for this purpose there be made an appropriation for the fiscal year ending June 30, 1848, of $50,000."

A similar case has long existed in the Ohio River, at Marietta, where the stream is divided into two channels by an intervening island. It has been generally acknowledged that one should be closed, so as to force all the water through the other.

In his official report, dated October 21, 1870, Major W. E. Merrill, a distinguished officer of the United States Engineers, remarks:

"At present the Ohio River at Marietta is bad in both channels at low water, and the bars in the two channels are about the worst in this portion of the river. * * * It is generally conceded that when the Ohio River is equally divided between two channels, neither is good in low water, and in such cases it is usual to close one of the channels and to turn the entire body of water into the other. The existence of this necessity at Marietta Island has long been recognized, but there are two opposing parties in interest, who have hitherto prevented any action in this case." * * *

"It is obvious that the river must be concentrated, and the parties in favor of either side can never be brought to agree."

A board of United States engineers, consisting of Major G. K. Warren, G. Weitzel, and William E. Merrill, examined the same subject, and under date of December 1, 1870, reported:

"The board having visited the locality and examined the questions involved, are of the opinion that the low-water navigation requires a dam to be placed across one of the channels to increase the depth of water in the other."

The opinions of the first hydraulic engineers in Europe, concurring in these views,

*Just what is now in progress in front of this city, with the difference that our danger is double, having two eastern outlets, Spanish River and Middle or Pinto Pass.

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might be quoted, but it is deemed unnecessary to pursue the point further. It is proper to add, however, that I availed myself of the opinions and advice of that distinguished hydraulic engineer, and our venerable citizen, Captain Albert Stein, before arriving at the settled conclusions on which I have acted, and that nothing but the prolonged and unexpected absence of the senior United States engineer officer on this station prevented me from consulting with him. Where so many authorities agree, I did not see the propriety of incurring a delay of months, at a heavy expense, that his name might be added to the list. When he at last returned, a courteous invitation was extended for him to call and examine all the surveys and data constituting the basis of your action, which he promptly declined.

Now that the United States Engineer Department has undertaken to further test the scheme of dredging a channel through the bay, and has the means to apply that test, I have deemed it best to advise you not to join with them in the joint execution of the work.

It would be exceedingly difficult, in the first place, to avoid interference and complications, which could only do harm, and then the test proposed involves an amount of money far beyond what my judgment would approve in an experiment of such doubtful success. That it is an experiment, I need only quote the distinguished Chief Engineer of the United States now on this station. In his report, dated the 26th of December, 1870, he recommends a large reduction of the dredging work proposed on this line by his predecessor, and adds, "My project is to make a cut of 200 feet in width through Choctaw Bar, and one of 250 feet through Dog River Bar; depth to be made first 11 feet in both channels, and eventually 13 feet. These widths will be sufficiently great to enable the Gulf steamers and harbor-tugs, with vessels in tow, to pass through the channel without difficulty, and their comparative narrowness will insure the stability of their navigable condition with much more certainty than if they were one-half wider. *At any rate, it will be much the wiser plan to await results*, (the italics are mine. B. B.,) with the dimensions proposed of channels, before augmenting the cost more than 50 per cent., to the probable detriment of navigation." Then follows an estimate for $737,565, to be expended in dredging experiments.

These dredging experiments have been so often made, and have so often failed, that I must confess to little faith in them, and shall be unwilling, at any time, to resort to them, except as adjuncts to more enduring works.

In June, 1837, the Mobile Examiner contained an advertisement signed by Captain W. H. Chase and Lieutenant J. G. Barnard, for dredging Dog River Bar to a depth of 12 feet. They estimated the whole cost of the work then at $150,000, of which $50,000 had been appropriated. About 1852 or 1853 another $50,000 was appropriated and expended on this same work. The senior of these two officers, the captain, has gone down to the grave full of years, and the young lieutenant is now a veteran and venerable general, but their successor here still estimates for several hundred thousand dollars to continue this experiment, and in his report of 1870 says that the depth of water on that bar has *decreased* from 10 to 12 inches since the soundings in 1852, which were less than in 1837. In the same report of the successor of the distinguished engineers is found the following, in relation to dredging on Choctaw Bar:

"The directions given by the superintending engineer were to execute one cut entirely through the bar, a distance of 2,700 feet, to a depth of 11 feet, following precisely the direction of the old channel. This through cut, averaging a width of 35 feet, was thought advisable so as to make the channel to the extent of the sweep of the dredge available as soon as possible for vessels drawing less than 11 feet. The cut, however, has been actually made to a depth of 13 feet, it having been found difficult with the dredge in use to restrict it to a less depth."

In his communication of February 20, last, this same officer says:

"Since the date of that report (26th December, 1870) the operations (dredging) have been continued on the Choctaw Bar Channel, so that at the present time a cut of from 60 to 70 feet has been executed from the north end of the channel to within 250 feet of the gap in the upper obstructions at the south end of the channel, to a depth of 10½ feet at mean low water. At this point the cut is only about 20 feet wide, and as the vessels passing through are obliged to make a turn at this place, it will be necessary to widen the cut for about 150 feet in length, to a width of not less than 60 feet, in order to obtain 10½ feet of water at mean low tide through the whole length of the channel."

At this date, then, February 28, 1871, there remained less than 700 cubic yards to be removed, not a week's work, to insure a channel 10½ feet deep at mean low tide, and not less than 60 feet wide. In fact, according to the author of the above, the channel was, of necessity, 13 feet deep.

With a view to lay before you the present condition of Choctaw Bar Channel, I have had it carefully sounded within the past month by competent assistants, aided by some of the best pilots in the harbor. Their soundings were made both longitudinally and across the channel at short intervals. The results show no such cut as the one referred to in these extracts. The work has doubtless been done, but it has not remained

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long enough to be found. In confirmation of this statement I submit the following certificates from two of the bay pilots, daily engaged in their avocation:

"MOBILE, *December* 30, 1871.

"This is to certify what water we can carry through Choctaw Pass Bar. At low water, 8 feet; high stage of water, 9½; general stage of tides' rise and fall, one foot and a half.

"JAMES LAMBERT,
"JOHN CARNEY,
"*Pilots, Dog River Bar.*"

After an expenditure in 1837-'38 of $50,000, and in 1854 of $50,000 more, on a work estimated to cost $150,000, we find "the depth of water has decreased from 10 to 12 inches," as is now reported, we may safely conclude that the expenditure of the recent appropriations of $100,000 more will be ample to satisfy all skeptics on this long-disputed question.

In the annual report of the United States Chief Engineer for 1871, I find the results of an examination of a similar work. The project was for re-opening Roanoke Inlet, near Nag's Head, North Carolina. Several plans had been proposed by different engineers; that of Lieutenant D. C. Woodbury, United States engineer, for dredging, was adopted. The report of this examination, dated Baltimore, 19th November, 1870, says:

"Congress appropriated $50,000 to commence operations; $40,000 have been expended, and at this time there is scarcely a trace to be seen of what has been done, the drifting sand filling in the trench as fast as it was excavated by the dredging-machine. In fact, the machine was very near being imbedded in the sand, it filling up so rapidly behind it, but was gotten out in time to save it.

"On my first visit to Nag's Head, in company with Lieutenant Whiting, of the Corps of Engineers, previously in charge of the work, I was perfectly satisfied of the entire impracticability of the scheme, and, in consequence, reported to the Bureau, recommending that the work should be abandoned, and the machinery and other public property sold; which report was approved by the honorable Secretary of War, and the property was sold on 15th of August."

In continuation of this subject, the report says:

"Now suppose a channel dredged through these last shoals, auxiliary to the re-opening of Roanoke Inlet, what would be most undoubtedly the effect after every western gale? Most assuredly, the light sand of the shoals would be lifted from their resting-place and carried along until they could find a lodgment in the new-cut channel, and this operation would so invariably and frequently occur as to very rapidly efface every trace of the cut, just as was the case with the trench made by Captain Woodbury.

"7th. Again, admitting that Congress should appropriate the largest sum estimated for the project, ($53,459.66,) and the work carried on with the utmost dispatch, it is very certain every westerly gale would fill the new-cut channel to such a degree as to make it an ever-recurring necessity to dredge it over again."

This excellent report, made by General J. H. Simpson, colonel of engineers, United States Army, then recommends an abandonment of the work, as "an unwarrantable waste of the public money."

I have no hesitation in expressing the opinion that the same result has attended, and will continue to attend, all dredging through the soft alluvial deposits and light sands of the shoals in Mobile Bay, until the concentrated current of the river is brought to bear upon them.

It is proposed, then, to postpone all dredging-operations by this board until that concentration is made above Choctaw Point, and not to decide on any definite plan of work below that until the results of the concentration are seen. By that time we shall also have a further test of the dredging-process, as an additional boat of greater power has been placed on the work in Choctaw Bar Channel.

Since the organization of your board, each of the two lines of obstructions have been opened to a width of fully 600 feet, a thorough survey of the whole city front has been made and mapped, a new wharf-line established, and the survey has been continued to include the river and bay from the head of Tensaw to a point below the city line on the bay-shore. Works are also in progress now to close Middle or Pinto Pass, to protect the lower end of Pinto Island from the washing of both the concentrated river and the heavy waves which break over it during high easterly winds, and to protect the lower part of the city front from further abrasion by the same cause. As soon as these works have been sufficiently progressed to justify it, others will be commenced above the city to concentrate more of the water into the main river, sweeping the city front.

Respectfully submitted.

BRAXTON BRAGG,
Engineer.

NOTE.—Since the date of the foregoing, the "Report of the Chief of Engineers,

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United States Army, for 1871, has been received and examined with great interest. The nature and location of many of the works, and the high professional standing of the officers reporting on them, give great value to their views in connection with our own similar case.

Attention is specially invited to the report of Major Howell, on the project for a ship-canal from New Orleans to Ship Island, dated New Orleans, February 9, 1871, (pages 524, 525, and 526,) and to another from the same officer, inclosing one from Lieutenant H. M. Adams, upon the project of a harbor at Mississippi City, and its connection with Ship Island Harbor, (pages 548, 549, and 550.)

ENGINEER OFFICE, BOARD FOR THE IMPROVEMENT OF THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, June 12, 1871.

To the president and members of the board, &c.:

GENTLEMEN: Herewith I have the honor to submit a map of Mobile River, from Bayou Warmouth (One-Mile Creek) to Choctaw Point, including Pinto Island and Pass, with cross-sections of that pass and the river taken at various points. The facts developed by this survey demand the most serious consideration.

By ordinance of the city, dated 4th April, 1857, a wharf-line was established for the whole city front, which provided "that no wharf nor other structure shall be built or constructed or extended, nor, if built, constructed, or extended, shall remain on the west side of Mobile River if it projects east beyond a line commencing at the northern line of the city, at a point from which a line running south 6° east shall strike a point in the northern line of Hunt (now Beauregard) street, extended a distance of 338 feet eastwardly from the west line of Front street; thence by a straight line to a point in the north line of Saint Anthony street, extended 252 feet eastwardly from the west line of Front street; thence by a straight line to a point on the north line of Conti street, extended 165 feet eastwardly from the west line of Front street; thence by a straight line to a point on the north line of Church street, extended 250 feet eastwardly from the west line of Commerce street; thence by a straight line to a point in the north line of Theatre street, extended 190 feet eastwardly from the west line of Commerce street; thence by a straight line to a point in the north line of Main (now Palmetto) street, extended 295 feet eastwardly from the west line of Water street; thence by a straight line to a point in the north line of New York (now Elmira) street, extended 550 feet eastwardly from the west line of Water street, and thence by a line running south 20° 20′ east to the bay." That line has been run out, and is laid down in the map now submitted. Before this line was adopted the city has encroached very seriously upon the water-way of the river, no less than 500 feet of that way along the main front having been filled and occupied by two streets and two blocks of buildings.

Had there been no other outlet for the river than this one channel, the water could have accommodated itself to the changed condition by cutting away the opposite bank, or by scouring the bottom to a greater depth. Unfortunately, nature presented an easier solution in the presence of other channels; and the facts established by the survey, when compared with the past, prove beyond question that, while the water in Mobile River is decreasing, that in Pinto Pass and Spanish River is increasing. This result can be attributed to no other cause than the obstructions thus placed in the natural way of the river.

The city authorities then prudently established the line of 1857, beyond which no structure should extend. Defective as this line was, it was the best, probably, that could have been done at that time, owing to antecedent errors which could not well be corrected. But, unfortunately, enforcement did not follow enactment. Built without reference to any plan, the wharves have been constructed and extended by individuals to serve private interests, and to meet temporary emergencies. Irregular in shape and length, with intervening slips, they have created eddies and stagnant pools, this causing a deposit of the sedimentary matter brought down by the stream, and of the heavy material washed in by the city drainage. As the depth of water decreased, from these causes, the wharves would be again extended, securing temporary relief at the expense of permanent injury. The slips would again be filled, and the remedy be repeated, until we are in absolute danger of forcing the main river into other channels. The examination of the map presents to you the alarming fact that nearly every important wharf north of the south side of Government street has been extended into the main river beyond the prescribed line, in some cases as much as 55 feet. Notwithstanding this, it will be perceived the slips are now so much filled by deposit that they afford no accommodation to commerce, and in the upper part of the city, even at the ends of these extended wharves, there is but 6 to 8 feet water.

To apply the proper remedy for this condition is much more difficult than to point

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out the errors which have produced it. Conflicting interests, private and public, must be reconciled. Sufficient space must be provided, not only for our present commerce, but for that which we seek and expect, and the water necessary to accommodate the commercial marine we invite to our port must be secured and preserved. The river has been narrowed at points to a degree which threatens us with its entire loss, and yet the land thus reclaimed has been built upon in places, especially at Government street and some distance above, until the space allotted to commerce, notwithstanding the large projection of the wharves beyond the established line, is barely sufficient.

The plan of wharves with intervening slips on a river-front, especially in a contracted stream which receives the city drainage in addition to its sedimentary matter, is never adopted except under a necessity which knows no law. This necessity could only arise from a want of space, an exposed position, or a great rise and fall in the tide. Neither of these reasons applies in our case. We have two miles of city front already available for the use of commerce, which can be extended to three miles at any time when business shall demand it. This is fully equal to half the space now appropriated in New Orleans, with five or six times our population, and reporting ten times our commerce. In a recent elaborate report from the department of docks in the city of New York, recommending an extension and improvement of the new wharves in that city, it is proposed to increase their wharf-line from twenty-eight to thirty-seven miles, which, it is argued, will be not only sufficient for the present commerce, but for the increase of an age. This extent only exceeds ours ten or fifteen fold, when her population is twenty-five, and her commerce probably one hundred fold of ours. The want of space, then, need not deter us from prosecuting this important work, as we shall be fully able to accommodate more than ten times the present commerce. Our position is so perfectly secure from storms, and our tides so insignificant, that neither of the other points requires examination.

The considerations in favor of a solid quay and continuous bulk-head along the whole city front are numerous and weighty. Such a structure would remove the many interruptions to a free and easy flow of the river-current along the whole city front, prevent the formation of eddies, by which deposits are now made, and secure a rapid removal, by the force of the current, of the vast quantity of offensive matter which now accumulates in the slips from the drainage of the city, and not only fills them and interferes with their use, but undoubtedly proves detrimental to the public health. All other things being equal, this one consideration of a constant stream of living water, pure, wholesome, and inoffensive, in lieu of the present cesspools of filth, nausea, and disease, should secure the adoption of the plan. As a sanitary measure alone it would more than justify the change.

The question of locating this line, now that the one of 1857 has been virtually abolished, is embarrassing. There can be no doubt that the public right of free navigation has been invaded; but vested rights are claimed under forms of law, and by long usage. The expense of restoring the old line would be large, in addition to the other perplexities. To avoid these difficulties, a new line is recommended as a compromise, which will be less expensive in construction than the restoration of the one already overbuilt, will cause much less dissatisfaction, and will afford more space for commerce. Unquestionably this will tend to injure the river to some extent, as all other encroachments have done, but this tendency can be overcome by the judicious expenditure on the other side of the river of half the amount necessary to restore the old line.

The initial point of the old line of 1857, being 338 feet in an easterly direction from the northwest corner of Beauregard and Front streets, narrows the river at that point to about 1,100 feet. This was injudicious, and, owing to the wide space devoted to commerce at that point, was unnecessary; but as the wharves from that down have been predicated on that official action, it is proposed to assume that as the starting-point of the new line. Above that it is not deemed necessary to recommend any change. Moving down we find the wharves are generally over the line as far as Government street, where the largest and most serious encroachment of 55 feet has been made. In front of the space between Saint Francis and Dauphin streets is a large and almost solid structure, extending 25 feet over the line on Saint Francis street. To remove this would be a serious and expensive work. Adopting it as a second point, connecting with the first, we have an uninterrupted straight line of over 3,000 feet. Everything projecting beyond this line should be promptly removed.

Below this second point we meet serious difficulties. The wharves between Dauphin and the lower side of Government streets project far beyond the legal and prudent line, and yet the space allotted to commerce, owing to the encroachments of commercial buildings, is very small—too small to be reduced without inconvenience. Thence from Government street down to Theatre, a distance of fully 1,000 feet, the city authorities, by ordinance dated 19th December, 1870, authorized an extension by the New Orleans, Mobile and Chattanooga Railroad Company, of their wharf-property to a line varying from 30 to 60 feet beyond the line established in 1857. This ordinance, it is true, was repealed by the succeeding city authorities in January, 1871; but the com-

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pany claims a vested right which could not be recalled. They are now engaged in the work of building out and piling the river to the line granted in December, 1870. The difficulty of restoring the line of 1857 above this railroad concession, serious as I regard the encroachment, induces me to suggest a compromise by which each party shall yield about half its claim. A point on the extension east of the upper line of Government street, 190 feet from the west side of Front street, would bring our line outside of Government street wharf. From that point, in a straight line, to the established point of 1857, opposite Theatre street, would give a line offering as little impediment to navigation as I could advise, and at the same time yield to commerce and to individuals all the concession which can be made without danger of serious consequences. It would slightly increase the concession to the railroad company at Government street, and reduce it below, but still be outside of, the line of 1857.

From the point opposite Theatre street, owing to the great reduction in the cross-section of the river from the head of Pinto Island, it is recommended that the line be drawn in, say, 65 feet on Elmira street. This change can be made without prejudice to any interests, as no wharves extend now so far as the line proposed.

The new line proposed would commence, then, at a point on the easterly extension of Beauregard street, 338 feet from the west line of Front; thence by a straight line to a point on the eastern extension of the south line of Saint Francis, 232 feet from the west side of Front; thence to a point on the eastern extension of the north line of Government street 190 feet from the west line of Front; thence to a point on the eastern extension of the north line of Theatre street 195 feet from the west line of Commerce, (line of 1857;) thence to a point on the eastern extension of the north line of Palmetto street, 245 feet from the west line of Water street; thence in a line to the southern boundary of the city, 50 feet west of the line of 1857.

Should the full claim of the New Orleans, Mobile and Texas Railroad Company be recognized, a change will be necessary from the line recommended between the points opposite Saint Francis and Theatre streets, viz: From the established point opposite Saint Francis to a point on the easterly extension of the north line of Church street, 310 feet from the west line of Commerce; thence to a point on the easterly extension of the north line of Theatre street, 195 feet from the west line of Commerce, (the point in the advised line.) This departure would make a serious encroachment on the river at a point where the water is now deflected, so as to throw it into Pinto Pass, especially as the measurements show a very serious result already. It might be compensated, however, by a counter-work on the opposite side of the river, which would control the current and restore the needed water-way.

Should the proposed plan of a solid quay be accepted, it would be proper to define Front street from Beauregard to Government, and Commerce and Water streets from Government down where they front on the river, and to prohibit all structures on the east side of these streets interfering with the free use of the quay for commerce.

Front street, from Beauregard to the south line of Saint Francis, might be 100 feet wide; from that point to Government, *to which it should be opened*, it would have to be contracted to 60 feet, so as not to encroach too much upon the space now devoted to commerce. This would give a solid and beautiful quay from Beauregard street to Government street, varying in width from 220 to 110 feet, and below Government varying, according to the line adopted, from 230 to 110 feet, with a constant, living stream of pure water, removing all offensive deposits, and keeping a uniform depth, which should be regulated to meet the wants of commerce.

The final and definite location of this wharf-line will control, in a great measure, the work necessary to secure the water-way, so as to give a proper width and depth. The plans for this can be soon perfected after that line is located.

No estimate of the cost can be made for building this bulk-head and quay until the line is located, and then the interests of private individuals and the city must be arranged before action in that direction.

Respectfully submitted.

BRAXTON BRAGG

ENGINEER OFFICE, BOARD FOR THE IMPROVEMENT OF THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, August 25, 1871.

To the president and members of the board, &c.:

GENTLEMEN: At your last meeting a resolution was adopted approving a front line of the city beyond which no wharf or other structure shall be built, and varying in no essential point from that suggested in my report of the 12th June last, though making some slight concessions with a view to avoid complications and delay. The city engineer fully concurs with me in recommending this line to the city authorities, and it

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is now before them for such action as in their judgment may seem proper. The line is probably the best that can be secured at this time.

WHARF-LINE.

The initial point is established on the north line of Beauregard street, extended a distance of 350 feet eastward from the west line of Front street; thence by a straight line to a point in the north line of Government street, extended 350 feet eastward from the west side of Commerce street; thence by a straight line to a point in the south line of Church street, extended eastward 285 feet from the west side of Commerce street; thence by a straight line to a point in the south line of Theatre street, extended eastward 210 feet; thence by a straight line to a point in the north line of Elmira street, extended eastward 485 feet from the west side of Water street; thence by a straight line bearing south 10° east. Above Beauregard street the line to run north 6° west. This line, when approved by the city authorities, I propose to have permanently designated by heavy piles, conspicuously marked, so that any official can see at a glance when future encroachments are made, and the most rigid accountability should be enforced.

The conclusions reached in my former report as to the effect produced in the main channel of the river by the long-continued encroachments, have been fully confirmed by subsequent data, and by further study of the plans and cross-sections prepared from the surveys.

Above the head of Spanish River the Mobile River has an average width of fully 1,200 feet, with a cross-section of 22,250 feet, and an ample channel-way of 30 feet depth. The same distance below the head of Spanish River, the width of Mobile River is found not to exceed 1,000 feet, with an average cross-section of only 13,000 feet, and a channel depth of only 15 feet. Examining further, we find this loss fully accounted for by the cross-section of Spanish River, showing 10,000 square feet and a channel-way 20 feet deep.

Following the Mobile River down, no material change is noticed until we reach the wharves of the city, except some 1,500 square feet added from the Chickasabogue and Three-Mile Creek. From the upper to the lower limits of the city serious encroachments have been made as reported in my last.

The tendency has been to force the water from the city front through Pinto Pass, and this tendency has been aided by the very serious encroachments on both sides of the river below the head of Pinto Island. As the result we find a width of only 640 feet for the main river, and a cross-section of only 7,500 square feet, just one-third of the water-way found above Spanish River. The natural effect is apparent just below, in the gradual growth of the marsh-flats on both sides of the river near the ends of Pinto Island and Choctaw Point. A continuation of these causes must soon close this channel, and ruin all wharf-property below Theatre street, and eventually up to Government street.

There is but one remedy for this unfortunate condition, produced by our own imprudence. Further encroachments must be stopped, the way must be opened, and the water must be brought back to the main channel. To open the way only, would leave it to be closed again by the same process, and we should have an unceasing, never-ending demand for dredging. Where the river is not obstructed above the city, nature preserves its own channel with an ample width and depth for all purposes; and it will do so in front of the city and below it, if we will only permit it to execute its own unerring laws.

In addition to the work of opening and controlling the water-way of the river, I have projected and advise the construction of a jettee below Choctaw Point, to prevent the further abrasion of the western shore of the bay, and drifting of the sand on to Choctaw Bar, by which the labor of dredging at that point is much increased, and the practical results at times greatly reduced. This work will also tend to prevent the spread of the river-water as it enters the head of the bay, and thereby aid in keeping open the channel whenever the dredging shall have been completed.

Recalling your attention to my report on this subject, dated June 12, last, I beg to submit the accompanying plans and estimates for the work necessary to carry out the suggestions then and now made, for restoring and controlling the channel-way of the river below the head of Pinto Island, and bringing back to its proper outlet so much of the water now diverted through eastern channels as may be necessary to accomplish this essential object.

Respectfully submitted.

BRAXTON BRAGG,
Engineer.

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The following is appended as showing work thus far accomplished by the board:

ENGINEER OFFICE, BOARD FOR THE IMPROVEMENT OF THE RIVER, HARBOR, AND BAY OF MOBILE,
Mobile, Alabama, August 29, 1871.

DEAR SIR: The deep interest felt by our own people, and by those with whom we have commercial relations, in the subject of our harbor-improvements, induces me, in reply to your inquiry, to furnish such information as my office now affords in regard to the progress of that important work.

At the time of the organization of this board under State laws, in March last, Captain Grant was engaged, under contract with the United States Government, in dredging Choctaw Point Bar, which operation is still in progress. A new contract for continuing this work as far as Dog River Bar has been let to a party from Chicago, who is now here to enter on the work, as I am informed. This dredging operation is under the control of General J. H. Simpson, United States engineer, an officer of high professional reputation and great experience in this specialty. Finding this part of the work thus provided for, the board of State commissioners undertook other branches of the operations equally necessary for the relief of commerce.

Two lines of artificial obstructions across the channel of the bay had been built during the war, intended to impede the passage of vessels—one near Choctaw Point Bar, the other below and where the channels of Spanish River and Mobile River re-unite. These had remained nearly in the condition left by the war, and were both difficult and dangerous, as they left a tortuous passage of only 200 feet in width. Under the direction of this board, both of these lines have been so opened as to straighten the channel, and afford a clear passage of more than 600 feet at each point. Vessels drawing 13 feet can now pass these points with safety and ease. In the prosecution of this work we have been greatly aided and much expense saved by the surveys and maps, as well as by the personal assistance, furnished us by General Simpson and his subordinates.

The attention of the board was early drawn to the changed and rapidly changing condition of the river in front of the city, and elaborate surveys disclose the necessity for large and important works, not only to check the progress of this evil, but to restore the river to its normal position and condition, And as it is no less important that the encroachments which have produced this condition shall be checked, the board has taken prompt action in the matter, and has invited the city authorities to co-operate.

A wharf-line for the whole city front has been adopted, and it has been determined that a solid quay and continuous bulk-head shall be substituted for the present projecting wharves and intervening slips.

Plans and estimates for important works opposite to and below the city, calculated to restore the river to a condition for the accommodation of a commercial marine, largely increased in number and size, are now ready, and the works will soon be under contract. These preliminary works for the amelioration of the condition accomplished or provided for, the board will direct its earnest attention to the main and great object of opening a depth of channel through the bay, already much improved, so as to admit a much larger class of vessels to our wharves. That this can be accomplished there is not a shadow of a doubt. We have examples of much more difficult works successfully completed, and the question here is simply one of time and means. A comprehensive plan once adopted and pursued with persistent energy, with ample means, and the end is easily seen. With the immense resources of Alabama in cotton, coal, and iron opened to the world, the cost of such a work would be repaid tenfold in one year by the increased business and value of our property. Even in Mobile alone we should soon realize the whole amount, in which all interests should participate. No one of the many important public works on which we are now engaged can surpass this, because the prosperity of each one of them is more or less involved in our success.

With a beginning which promises entire success, and means already provided ample to execute a great part of the plan proposed, may we not look to the State and General Governments to come to our aid, and insure the completion of a work second in importance and value to no other public enterprise in the country?

Very respectfully, yours,

BRAXTON BRAGG,
Engineer to the Board.

Colonel CHARLES FORSYTH,
Secretary Board of Trade.

APPENDIX B.

AN ORDINANCE to define and establish the eastern line of the wharf-front of the city of Mobile.

SECTION 1. *Be it ordained by the mayor, aldermen, and common council of the city of Mobile,* That the eastern line of the wharf-front of the city of Mobile be, and the same is

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hereby, established as follows: The initial point to be established on the north line of Beauregard street, extended a distance of 350 feet eastward from the west line of Front street; thence by a straight line to a point in the north line of Government street, extended 350 feet eastward from the west side of Commerce street; thence by a straight line to a point in the south line of Church street, extended eastward 285 feet from the west side of Commerce street; thence by a straight line to a point on the south line of Theater street, extended eastward 210 feet; thence by a straight line to a point in the north line of Elmira street, extended eastward 485 feet from the west side of Water street; thence by a straight line bearing south ten degrees east, above Beauregard street, the line to run north six degrees west.

SEC. 2. *Be it further ordained*, That the limits prescribed for the wharf-front by section 413 of the code of ordinances of 1860 be, and the same are hereby, amended so as to conform to the provisions of section 1 of this ordinance; and that section 414 of the said code be, and the same is hereby, repealed.

Approved September 16, 1871.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, March 23, 1872.

GENERAL: On the 18th instant I had the honor to inform you that I had, as directed by you, furnished the "State board for the improvement of the river, harbor, and bay of Mobile" with a copy of the report of the board of United States engineers, recently convened in this city by virtue of Special Orders No. 4, Headquarters Corps of Engineers, Washington, D. C., of January 6, 1872, for the purpose of preparing a plan for the improvement of this harbor. Since then there has been the following correspondence, a portion of which has been already communicated, but which I think proper to present in a connected form:

"OFFICE OF THE BOARD FOR THE IMPROVEMENT OF
"THE RIVER, HARBOR, AND BAY OF MOBILE,
"*Mobile, March* 18, 1872.

"SIR: I have the honor to acknowledge the receipt of your note of 16th instant, inclosing copy of letter of 12th instant to you from General A. A. Humphreys, Chief Engineer United States Army, and copy of the report of the board of engineers, United States Army, recently convened at Mobile under Special Orders No. 4, from Headquarters Corps of Engineers.

"At an early day the papers will be laid before this board and its action thereon communicated to you.

"I am, very respectfully, your obedient servant,

"PERCY WALKER,
"*Secretary, &c.*

"General J. H. SIMPSON,
"*Engineer, United States Army.*"

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, March* 18, 1872.

"SIR: On the 16th instant, agreeably to authority from Brigadier-General A. A. Humphreys, Chief of Corps of Engineers, United States Army, dated 12th instant, a copy of which was inclosed, I had the honor to furnish your board with a certified copy of the report of the board of United States engineers constituted by Special Orders No. 4, Headquarters Corps of Engineers, of January 6, 1872, to report a plan for the improvement of the bay of Mobile.

"The letter referred to also informed you that said report had been approved by the Chief of Engineers and Secretary of War, and that I have been directed to conform to the views and recommendations of said United States board in all matters relating to the improvement of the harbor.

"In yesterday's Register, a daily newspaper published in this city, I noticed the following advertisement:

"'*To contractors.*

"'ENGINEER OFFICE, BOARD FOR IMPROVEMENT OF THE
"'RIVER, HARBOR, AND BAY OF MOBILE,
"'*No.* 38 *North Royal street, Mobile, March* 16, 1872.

"'Sealed proposals will be received at this office until 12 m., 20th March, 1872, for repairing and extending two jettees at the head of Spanish River.

"'Specifications of the work, with the terms and conditions, may be seen at this office from 9 to 3 o'clock, daily.

"'BRAXTON BRAGG,
"'*Engineer.*'

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"The foregoing notice to contractors, showing that your board are contemplating the partial closing of Spanish River at its head, by repairing and extending two jettees at that point, which works are in direct conflict with the views and recommendations of the United States board, as shown in their report, as the General Government engineer officer in charge of the improvement of the harbor of Mobile, I respectfully but earnestly protest against the construction of any such works by your board, or of any other which will conflict with said report.

"I am, very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Brevet Brigadier-General and Colonel of Engineers, U. S. A.*

"PERCY WALKER, Esq.,
"*Secretary of Board for the Improvement of the River, Harbor, and Bay of Mobile.*"

"OFFICE OF THE BOARD FOR THE IMPROVEMENT OF
"THE RIVER, HARBOR, AND BAY OF MOBILE,
"*Mobile, March* 18, 1872.

"SIR: Your note of this date referring to the advertisement by General Bragg, engineer of this board, calling for proposals for repairing and extending two jettees at the head of Spanish River, published in the Mobile Daily Register of 17th instant, and protesting against the construction of that work, has just been received. Your note seems to have been written under the impression that this board had approved of said work after being informed of the report by the board of engineers recently convened in this city.

"Permit me to disabuse your mind of this impression. The report was not received by me until this morning, an hour or two before I dispatched my note of this date acknowledging receipt of yours of 16th instant with its inclosures, and has not yet been seen by any member of the board.

"As my note of this morning stated, a meeting of the board will speedily be held for the purpose of acting on the report, and, without delay, you shall be advised of its action.

"Very respectfully,

"PERCY WALKER,
"*Secretary, &c.*

"General J. H. SIMPSON,
"*Engineer, United States Army.*"

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, March* 19, 1872.

"SIR: Your letter of 18th instant, acknowledging receipt of my letter of same date protesting against the construction by your board of certain contemplated works at the head of Spanish River, and stating that a meeting of said board would speedily be held for the purpose of acting on the report of the United States board recently convened in this city, was received by me last evening.

"I am, very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Brevet Brigadier-General and Colonel of Engineers, U. S. A.*

"PERCY WALKER, Esq.,
"*Secretary of Board for the Improvement of the River, Harbor, and Bay of Mobile.*"

"OFFICE OF THE BOARD FOR THE IMPROVEMENT OF
"THE RIVER, HARBOR, AND BAY OF MOBILE,
"*Mobile, March* 21, 1872.

"SIR: I have the honor to inform you that a meeting of this board was held this day, and your communication to me of the 16th instant, together with the letter to you from General A. A. Humphreys, United States Army, and the report of the board of engineers recently convened in this city to prepare a plan of improvement of harbor of Mobile, was laid before it.

"The action of this board thereon will appear from the following extract from the minutes, a copy of which I was instructed to furnish you with:

"'General J. H. Simpson, engineer United States Army, stationed at Mobile, having, since the last meeting of this board, held on the 15th instant, communicated a copy of the report of the board of engineers, United States Army, convened at this city under a special order from headquarters at Washington, D. C., to prepare a plan for the improvement of the harbor at Mobile, and it appearing from said report that the repair and extension of the jettees at the head of Spanish River directed by this board at said last meeting to be made are not in conformity with the plan of improvement proposed in said report and approved by the Chief of the Engineer Corps and the Secretary of War, and this board not having power to carry out any scheme of improvement

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not sanctioned by the authority of the United States, and regarding it as a duty to use the means at the disposal of this board in aid of the plan marked out in the report: therefore, and upon the suggestion of the engineer, the directions given at the said last meeting are hereby recalled, and the secretary is instructed to inform General Simpson thereof, and that this board holds itself in readiness to enter upon such portion of the work contemplated in the report as he may indicate, and he is respectfully requested to inform this board of such designation as soon as possible, in order that due preparations may be made by this board.'

"Very respectfully, your obedient servant,

"PERCY WALKER,
Secretary, &c.

"General J. H. SIMPSON,
"*Engineer, United States Army, Mobile, Alabama.*"

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, March 22, 1872.*

"SIR: I have the honor to acknowledge the receipt of your letter dated yesterday, communicating the resolution formed by your board same day, to the effect that they had recalled their order directing the repair and extension of the jettees at the head of Spanish River, and that they would, in subordination to the plan recommended by the report of the board of United States engineers, and approved by the Chief of Engineers and the Secretary of War, aid to the extent of the means at their disposal in the improvement of the harbor of Mobile.

"I am gratified with the receipt of this resolution, showing, as it does, a harmony of action on the part of the State board and United States Engineer Department, which cannot but be productive of the happiest results.

"In accordance with the wish of the board, that I should designate the portion of work to be assigned to them, in order that they may enter upon it at the earliest moment, I respectfully state that the lower portion of Dog River Bar Channel will be immediately staked out; and it is recommended that the board commence at the northern limits of the upper-fleet anchorage, or 12-foot curve, and dredge to a least depth of 13 feet in the channel from that point, making, at first, one thorough cut (to the extent of the sweep of the dredges) from south to north, and that the material thus excavated be deposited as far on the west shore of the bay, say the 6-foot curve, as can be approached by the dumping-scows.

"The soundings have already been made over the said bar, but, allowing for unfavorable weather at this season of the year, it is not believed the channel can be staked out ready for your operations till Monday the 11th of April next.

"Very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Brevet Brigadier-General and Colonel of Engineers, U. S. A.*

"PERCY WALKER, Esq.,
"*Secretary of Board for the Improvement of the River, Harbor, and Bay of Mobile.*"

The foregoing correspondence showing that the State board recognize fully the paramount authority of the General Government to prescribe a plan for the improvement of the harbor, and that it is their purpose to aid in carrying out such plan agreeably to the report of the United States board, and to enter upon the work so soon as I shall indicate the portion to be assigned to them, and the following extract from said report setting forth the great necessity of large appropriations for the immediate and rapid excavation of Dog River Bar Channel, at present the only great obstruction in the channel of approach to the inner harbor, I respectfully and earnestly recommend that the appropriation I have asked for this object, in my last annual report, to wit, $100,000, be augmented at least to $200,000, and that this recommendation be laid before Congress at its present session, and at the earliest possible moment.

The following is the extract alluded to:

"As to the direction of this artificial channel the board concur with that of 1860, and with both the engineer officers in charge of the Mobile Harbor improvements, that the line of deepest water should be followed as it has existed for the past fifty years, since this line must now be regarded as a resultant of a fixed regimen of the different rivers uniting to produce this channel. The curve at the upper obstructions should be made as gentle as possible, and the opening or width of channel in that part somewhat increased, to admit the ready passage of the largest class of vessels that may enter the inner harbor of Mobile. It is recommended that this excavation be restricted to a width of 200 feet throughout its length, at least until its comparative permanency can be tested or established. *The board give it as their opinion that this excavation should be made as rapidly as possible*, for, if portions only are dredged and left in an uneven or lumpy condition, such portions will fill to the level of the projections; and besides, there will not be a clear water-way for the ready movement of the bottom current

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until each bar is cut entirely through and finished to an even surface. If, on the other hand, this dredging should proceed slowly and at intervals, it will be but a partial success. No good results can be predicted, except from a rapid and thorough execution of the work."

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

O 2.

SURVEY OF THE MOUTH OF APALACHICOLA RIVER.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, March 28, 1872.

GENERAL: I have the honor to submit herewith the reports of Captain A. N. Damrell, Corps of Engineers, United States Army, and of Mr. C. F. Trill, civil assistant engineer, on the survey of the mouth and bay of Apalachicola River, with a view to their improvement for purposes of navigation, authorized by the act of Congress approved July 11, 1870.

While these reports treat of the improvement of the channels of approach to Apalachicola, I would recommend only as feasible within reasonable limits of expenditure, as recommended by Captain Damrell, the dredging of a channel through the bar at the mouth of the river in the bay, from the 11-foot curve on the inside by the shortest line from deep water to deep water, which is also the line of deepest water in the natural channel, 100 feet wide and 11 feet deep; the width to be afterward increased, if found proper from the success of the first cutting, to 150 or 200 feet, as may be found advisable.

A channel to allow vessels drawing 11 feet of water to pass up to the city, 100 feet wide, would require the excavation of about 200,000 cubic yards of sand and mud, which, at 50 cents per cubic yard, would cost about $100,000, $50,000 of which I recommend should be appropriated by Congress for early operations.

For a channel same depth, and 200 feet wide, about 375,000 cubic yards of excavation, at 50 cents per cubic yard, would cost about $185,000.

It will be noticed that Mr. Trill discusses the project of opening a channel through the eastern part of Apalachicola Bay, (Saint George's Sound,) from the upper anchorage to the East Pass, and also a channel through New Inlet. As neither of these projects promises any permanent improvement, except at very large outlay, both original and constantly recurring, and the project of keeping open the New Inlet Channel at its mouth, as proposed by Mr. Trill, by parallel piers extending out to a depth of from 50 to 40 feet, I consider not feasible within allowable limits, I cannot recommend any appropriations for either of these projects.

As connected with the improvement of the harbor and bay of Apalachicola, I also forward herewith the report of Mr. Trill on the survey of the Chattahoochee River.

Mr. Trill has grouped the obstructions into three classes, depending upon the extent to which it may be deemed expedient to improve the river at those points. The first class, at low water, actually stops navigation. The second class is about a foot better in depth of water, but yet need improvement very much. The third class is not of much im-

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portance, but ought to be improved, if possible, to prevent changes for the worse in future.

His estimate for the first class, throughout the whole river, from Columbus to mouth at Apalachicola	$464,000
For the second class	327,000
For the third class	85,185

He recommends the first estimate, or $464,000, as being the only one which will comply with the requirements of unobstructed navigation at all stages of the water, and warrant the efficacy and permanence of the improvements.

In addition, he estimates for completion of survey of the Chattahoochee River	$5,000
Survey of Flint River, very much needed	8,000
Survey of Apalachicola River, on account of the difficult local circumstances, especially from Rico's Bluff, Florida, down	10,000

In conclusion, I would recommend immediate appropriations, as follows: $50,000 for the improvement of the harbor and bay of Apalachicola River; $50,000 for the improvement of the Chattahoochee River below Columbus; $5,000 for the continuation of the survey of the Chattahoochee River below Eufaula, to its junction with the Flint; $8,000 for the survey of the Flint River; $8,000 for the survey of the Apalachicola River.

The maps illustrative of the Chattahoochee River survey are one index map, one sketch, and fourteen detailed maps—in all, sixteen.

Those illustrative of the Apalachicola Bay survey are four in number.

All these maps are forwarded to-day by mail in a separate roll.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

REPORT OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS, UNITED STATES ARMY, ON THE IMPROVEMENT OF THE MOUTH OF APALACHICOLA RIVER.

MOBILE, ALABAMA, *October* 15, 1871.

COLONEL: On the 19th of January, 1871, I received the following letter of instructions from you relative to the examination and survey of the mouth of the Apalachicola River:

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, January* 19, 1871.

"SIR: Having been notified by Mr. James Green, of New York, that, on the 16th instant, he expressed the necessary instruments for the survey of the mouth of the Apalachicola River, you will take measures for the immediate prosecution of that work.

"The purpose of the survey is to ascertain the exact requirements for the improvement of the navigation at that point, and it is important that this information, if at all possible, be obtained for the use of Congress at its present session.

"I have appointed Mr. C. F. Trill your assistant, whom you will direct to proceed at once to Apalachicola, via first steamer from New Orleans, with the proper instructions to inaugurate the survey, pending your official visit to Ship Island and the arrival of the instruments.

"On your return from Ship Island, and after the arrival of the instruments, you will yourself repair to Apalachicola, via New Orleans, and take personal charge of the survey. Mr. Trill's pay will be at the rate of $150 per month.

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"The survey accomplished, you, with your assistant, will return to this office for the purpose of plotting your work and reporting results.

"I am, very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Colonel of Engineers, United States Army.*

"Captain A. N. DAMRELL,
"*Corps of Engineers, present.*"

On the same day Mr. Trill received instructions to proceed to Apalachicola.

As soon as the instruments were received, I followed Mr. Trill by the first steamer, and, on the 28th of January the survey was commenced, and continued as rapidly as the very unfavorable weather which prevailed would allow, until the 23d of April, at which time I received and carried out the instructions contained in the following letter from you:

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, April* 20, 1871.

"CAPTAIN: I am anxious to take advantage of my leave of absence at the earliest possible moment. I therefore desire you to turn over the survey with which you are charged to your assistant, Mr. Trill, leaving with him full instructions to insure the proper completion of the survey. After completing this duty you will return on the Poe, and report in person at this office.

"You are authorized to retain the Poe as long as may be necessary to enable you to turn over the survey to Mr. Trill to your satisfaction.

"I am, very respectfully, your obedient servant,

"J. H. SIMPSON,
"*Colonel of Engineers, United States Army.*

"Captain A. N. DAMRELL,
"*Corps of Engineers, Apalachicola, Florida.*"

I have the honor of submitting the following report of the survey, during the period I was in personal charge, and the report of Mr. C. F. Trill of subsequent work, accompanied by maps and estimates illustrative. It was presumed that the object of the survey was to determine—

I. The importance of improving the Apalachicola River, at its mouth, as indicated by the present and prospective commerce of the port of Apalachicola.

II. The practicability of such improvements.

III. The best means of making it.

IV. Its cost.

I. The importance of improving the Apalachicola River at its mouth, as indicated by the present and prospective commerce to be benefited.

Apalachicola is the port at which centers all the commerce to be benefited by the improvement in question.

Present commerce.—It is a city at present of about eighteen hundred inhabitants, situated at the mouth of the Apalachicola River, where it empties into Saint George's Sound, and on the west bank of the river. Its commerce is comparatively small, consisting of the receipt, yearly, by river, of a few thousand bales of cotton, a few hides, and a small amount of lumber, for shipment, and, by steamer from New Orleans, Louisiana, a variety of merchandise, for the supply of Apalachicola and the various cities, villages, and plantations along the Apalachicola, Flint, and Chattahoochee Rivers. The extent and value of this traffic I do not know, as it was not furnished, though repeatedly requested of parties who should have known and have been interested in giving the information; the only data at hand is the following tabular statement, furnished by the deputy collector of customs from the records of the custom-house:

	ENTERED.		CLEARED.	
Year.	No. of vessels.	Tonnage.	No. of vessels.	Tonnage.
1866	170	61,728.93	170	61,728.93
1867	105	33,128.70	100	32,025.70
1868	107	25,073.82	112	30,073.80
1869	200	75,129.80	175	64,180.20
1870	150	49,150.75	175	58,230.20

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Prospective commerce.—As the past commerce may have some bearing on the settlement of the question of the prospective commerce, I would state briefly that for several years before the war the trade and population of Apalachicola steadily increased till 1860, at which time it reached its maximum, and then had a population of about 6,000. With regard to its trade at that time I quote the following facts, set forth in a memorial of the city of Apalachicola to the State legislature, taken from the Floridian and Journal:

MEMORIAL OF THE CITY OF APALACHICOLA.

TALLAHASSEE, FLORIDA, SATURDAY MORNING, *December* 1, 1860.

HOUSE OF REPRESENTATIVES, *November* 27.

Read and ordered to be printed.

To the General Assembly of the State of Florida:

SENATORS AND REPRESENTATIVES: We, the undersigned, citizens of Apalachicola, respectfully petition that you will amend the act of January 10, 1855, entitled "An act to improve the navigation of the harbor and bay of Apalachicola," by authorizing the city of Apalachicola to issue bonds for the sum of $25,000, and that you appropriate the sum of $2,500 per year, for the space of ten years, out of the State's tax of Franklin County, to pay said bonds; the city of Apalachicola to pay the interest on said bonds.

With this amount of money we can cut through the Bulk-head, which obstructs the inner harbor, and thereby afford a passage through the whole of Saint George's Sound to vessels carrying 12 feet of water. We can also clean out the channel, so as to bring 11 feet and 12 feet of water up to the wharves of the city, while at present we have but 6½ feet of water in the channel at high tide. This appropriation would be fully capable of having this great work accomplished. We can purchase the necessary machines, our own citizens can do all the work, and, with the powers given us under the act of 1855, we will have ample means to keep the channel open.

This work would increase the value of a great portion of the city. It would open a large lumber business, it would greatly increase the business done in naval stores, and it would naturally lower the charges on cotton shipped from here and on goods received at this port. The revenue of the State would be greatly increased by the increased amount of taxes which this city would pay.

The commercial importance of this city justifies us in demanding this as a right. We are the great depot of the State. We do more business than each and every other portion of the State put together.

This year we have done over $14,000,000 worth of business. Our foreign export trade, from the 1st of September, 1859, to the 1st of August, 1860, was $3,209,570, being an increase over last year, on foreign exports, of $1,005,895, and we have every hope of an increase next year of our foreign trade. The foreign imports received at this port from the 1st of January, 1859, to 1st of August, 1860, were as follows:

Salt	$19,101 36
Sundries	4,685 47
Molasses	9,529 49
Total	33,316 32

Foreign cotton exports shipped from 1st of September, 1859, to 1st of August, 1860.

Destination.	No. bales of cotton.	Value of cotton.
To Liverpool	52,577	$2,832,524 19
To Liverpool	391	28,230 57
To Gibraltar	2,068	116,200 00
To Havre, France	1,420	91,396 50
To St. Petersburg, Russia	2,634	151,219 07
Total foreign cotton trade	59,090	3,209,570 33

Foreign shipments destroyed and partially destroyed by fire at the anchorage during the year, 2,171 bales of cotton for Antwerp, and 2,351 bales for Liverpool, value about $258,610. We have received from the 1st of September, 1859, to 1st August, 1860,

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133,079 bales of cotton, worth about $7,319,345; of this, 71,166 bales were shipped to domestic ports, 59,090 to foreign ports. Residue on hand for shipment. Now, add to this the gross value of tobacco, hides, cedar, lumber, &c., shipped from this port, and the gross value of merchandise received from all ports, and which is consumed and forwarded at Apalachicola, and comes into our harbor, and it will be found to exceed $14,000,000. In this trade there have been cleared at the custom-house at this port, from the 1st of September, 1859, to 1st of August, 1860, 148 vessels; of this number, 31 ships carried freights to foreign ports, and 117 to domestic ports.

This is by far a greater amount of business than all the ports of this State added together can show, except this city. To do so great an amount of business you will readily perceive that there must necessarily be a great amount of capital and commercial ability at this city.

* * * * * *

SAMUEL BENEZET,
Mayor of City of Apalachicola.
W. D. MACLAY,
G. THIGHAM,
J. M. HUNTER,
ANSON HANCOCK,
Councilmen.
GEO. BUCKMAN,
President of Atlantic and New Orleans Steam Navigation Company.
RICHARD G. PARKER,
President of Apalachicola Chamber of Commerce.

And one hundred and thirty-six others.

OFFICE OF COLLECTOR OF CUSTOMS,
District of Apalachicola:

I, George L. Brockenbrough, deputy collector of customs, do hereby certify that the report and statement of the foreign imports and foreign exports in the above memorial are true and correct, as appears from the records of this office; and, from the best information, I believe the value of the business therein stated to have been done at this port from the 1st of September, 1859, to 1st of August, 1860, to be correct.

Given under my hand and seal of office this 8th day of August, 1860.

GEO. L. BROCKENBROUGH,
Deputy Collector of Customs.

During the war the commerce of Apalachicola was almost entirely destroyed, but the year after, (1864,) I understand that the amount of business done there equaled, if it did not exceed, that of 1860. The cotton receipts for 1864 I have heard stated as 129,000 bales. Since that time the commerce of the place has steadily and rapidly declined. This loss of trade is due, I think, to two causes; partly and primarily, perhaps, to the bar at the mouth of the river, preventing vessels from coming to the wharves of the city, but compelling them to anchor nearly three miles off, and to lighter their cargoes; but principally it is due to the superior advantages offered for getting the cotton to market by the various railroads tapping the Chattahoochee and Flint Rivers, and passing through the section of country depending before on Apalachicola to the Atlantic ports, especially to Savannah, to which place probably the greater portion of the commerce lost by Apalachicola has been drawn.

Whether it would ever return, with the harbor improved, is questionable, though undoubtedly the port of Apalachicola would offer advantages, if improved, for shipping the products of and supplying an extensive region along the Apalachicola, Flint, and Chattahoochee Rivers, and the various railroads meeting them.

The length of the navigable portion of these rivers, according to the statements of river-pilots, is as follows:

	Miles.
The Apalachicola River, from its mouth to its head, the junction of the Chattahoochee and Flint Rivers	150
The Chattahoochee, from the junction with the Flint to Columbus, head of navigation	250
The Flint, from same point to Bainbridge, head of navigation	50
Total	450

On the Chattahoochee are the flourishing cities of Columbus and Eufaula, six towns, seven warehouses, and ninety-one other landings.

On the Apalachicola River are the city of Apalachicola, the towns of Bristol and Chattahoochee, two warehouses, and thirteen other landings.

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On the Flint, Bainbridge, two warehouses, and ten other landings.
The railroads referred to are as follows:
Centering at Columbus, are—
1. The Georgia Central, from Macon to Savannah, with a branch from Macon to Atlanta, connecting with Columbus via Southwestern.
2. Mobile and Girard, through Union Springs, where it crosses the Montgomery and Eufaula, to Troy, Alabama, its present terminus.
3. Montgomery and West Point, (branch to Columbus.)
4. (Under construction.) Bainbridge, Cuthbert, and Columbus.
5. (Under construction) North and South, from Columbus to Rome.
Centering at Eufaula, are—
1. Eufaula and Montgomery.
2. Southwestern Railroad, of Georgia.
3. (Under construction.) Vicksburgh and Brunswick, (built as far as Troy.)
At Fort Gaines—
A branch of the Southwestern.
At Chattahoochee—
Jacksonville and Pensacola, (running from Jacksonville to Chattahoochee.)
At Bainbridge—
Atlantic and Gulf, (to Savannah.)

Supposing, however, the cotton-trade of the country bordering on the rivers and railroads enumerated to be permanently lost to Apalachicola, there is another, already commenced, which cannot be taken away, and which might become very extensive, and that is the lumber-trade. Not having time or opportunity to make a personal reconnaissance to determine the extent of the resources of the country for this business, I have been obliged to conform myself to statements received from parties supposed to be acquainted with the matter.

The following extracts are given from a paper drawn up by P. W. White, esq., and P. Wise, the latter engaged in the lumber business at Apalachicola, and the former extensively acquainted with the country:

"From the Apalachicola and Chattahoochee Rivers, as far up as the Alabama line, westward to Pensacola and sixty miles south of the Alabama line, is an unbroken forest of the finest quality of yellow-heart pine, much of it of the description called soft yellow pine. This body of timber is about one hundred and thirty miles in length, east and west, and about sixty miles in breadth, north and south. There are some bodies of rich hummock and planting land in the vicinity of Marianna, county-site of Jackson County, and some smaller ones in the counties south, southwest, and west of Jackson.

"This body of timber is almost untouched, except near the Choctawhatchee, Escambia, and Pensacola Bays, whence the lumbermen of those places have drawn their supplies for years.

"The Chippola River, rising in Southern Alabama, about twenty-eight miles west of the Chattahoochee, flows in a southerly or southeasterly direction, about one mile to the east of the town of Marianna, and empties into the Apalachicola River about forty miles above Apalachicola. This stream runs through the heart of the timber regions of Calhoun and Jackson Counties, all of which can find a safe outlet through the Chippola and Apalachicola, with some improvement of the former.

"In addition to the pine-forests bordering this stream, there are immense bodies of the finest cypress, extending from above Marianna to its confluence with the Apalachicola, some of it of very great size and length, and generally sound and of easy access. Much of it stands in water deep enough to float it out from where it is cut to the open river.

"There is also a great deal of white-oak and poplar and other valuable woods in the valley of the Chippola, which contribute to the value of its resources.

* * * * * * *

"From the Georgia line, east for twelve miles and south as far as the waters of Saint George's Sound, is a country abounding with a great deal of fine yellow-pine timber. This body of timber, some of it of superior quality and some not so good, extends from the Georgia line to within twenty miles of Apalachicola, as low down on the river as Bloody Bluff, seven miles below Fort Gadsden.

"Below that point the pine is not accessible from the river.

* * * * * * *

"From the Florida line up as far as forty miles above Albany, Georgia, on the Flint, and thence east and west for hundreds of miles, into South Georgia and South Alabama, a belt of the finest timber to be found anywhere in the South, extending several hundreds of miles, east of the Flint, west of the Chattahoochee, and between the two for nearly a hundred miles north of the junction of the two."

Mr. Johnson, a ship-carpenter who resides here, informs me that he has worked the yellow pine from Spring Creek, which rises between the Chattahoochee and Flint

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Rivers and empties into the latter, and that it is of the best quality of that kind of timber which is used in ship-building.

Spring Creek is a stream of considerable extent, on which great quantities of this timber abound, and which affords an outlet for it into the Flint.

The same may be said of the pine on both sides of the Flint and Chattahoochee, extending up into Southern Georgia and Alabama, until you approach the hilly country, say forty or fifty miles south of Macon.

Few mills have been erected in all this vast region, and those which have are for supplying a local demand, which consumes a comparatively small amount of the timber.

* * * * * * *

There are already three saw-mills, with capacity of 160,000 feet per day, in operation in Apalachicola, and two others, I have been informed, are projected.

The lumber for the mills is cut on the Apalachicola, Chattahoochee, and Flint Rivers, and the various streams flowing into them, rafted down to Apalachicola, and there sawed and shipped.

To sum up, there has been a large cotton-trade at Apalachicola, which might possibly be restored by improving the harbor, and there will probably be a large lumber-trade built up by the same improvement, as the material and water transportation are at hand and the trade is already commenced.

Supposing it, therefore, to be desirable to make the improvement, the next question which arises is its practicability.

Apalachicola River empties into Saint George's Sound, which is a long, shallow expanse of water, about thirty-six miles from east to west, and varying in width from about six and one-fourth miles from north to south, at Apalachicola, to about three and one-fourth miles, at the west end of Dog Island.

Saint Vincent's Island stands between this sound and the Gulf of Mexico to the westward, leaving a narrow, shoal entrance between it and the main-land, called Indian Pass, and another one between it and Sand Island, called West Pass. From this pass a small island, called Sand Island, and a long, narrow sand-spit, partially covered with timber, and from one and one-fourth miles wide near its west end to one fourth mile near its eastern extremity, called Saint George's Island, extend about twenty-six miles, closing the sound from the Gulf to the southwest and south, with but two openings, one between Sand Island and Saint George's, narrow and shoal, and the other nearly south from Apalachicola, called New Inlet, which was broken through by a gale on 2d of September, 1837, with about 10 feet of water at that time.

At the east end of Saint George's Island is another outlet to the Gulf, about three and one-fourth miles wide, called East Pass, separating Saint George's and Dog Islands, which latter extends from this pass along the south of the sound, about six miles farther. East and West Passes are the ones used by the commerce of Apalachicola.

The West Pass, principally used, allows vessels drawing 11½ feet of water to sail over the outer bar at mean low water and run up to the lower anchorage, a distance, by the channel course, of about seven and one-fourth miles. From this point there is 11 feet of water (excepting a small distance of 10 feet) to the upper anchorage, a distance of about ten miles by course. From this point to the city the water shoals to about 4 feet on the crest of the bar, about one mile from the city, and again deepens to over 20 feet in the river in front of the city.

The East Pass, sometimes used, has a depth over the outer bar and up to the East Pass anchorage, a distance of about five miles, by course, of 14 feet, and at the anchorage there is 20 feet of water and a good holding-ground.

From this point the water gradually shoals to the westward toward the city, and within a few miles the bottom becomes very irregular, or lumpy, with a succession of shoals and deep holes. A short distance farther is a bar, or irregular shoal, making out from the main-land almost to Saint George's Island, called Porter's Bar, which throws the deep water line to the south, and makes a sharp bend in the course of the deepest water. Beyond this bar and about nine miles from the East Pass anchorage, and about four and three-quarters from the upper anchorage, mentioned in connection with the West Pass, is an irregular bar or shoal extending all the way, in a southerly direction, from the main-land to Saint George's Island, completely closing the sound in this direction, with a depth of water on it, at the point where it is usually crossed by vessels running on the sound, of about 5 feet, which can be carried through to East Pass, and the greater portion of the distance 10 and 11 feet.

It will be seen from the above that a bar at the mouth of the river (Apalachicola) blocks the way to the city, both by the East and West Passes, and, in addition, by way of the East Pass the course of vessels is obstructed by the Bulk-head, Porter's Bar, and the Lump.

The conclusion is, therefore, evident that the first thing to be done, in order to improve matters, is to open this bar at the mouth of the river, so that vessels which now come up by way of the West Pass to the upper anchorage can continue up to the wharves of the city. This bar is formed by the combined action of the currents of the river and those formed in the sound by the winds and waves meeting, producing still

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water, and thereby causing the deposit of sedimentary matter, carried along by the water when in motion, both the mud of the river and the sand from the beach, abraded by the other currents produced by the winds and tides.

The river-currents and those formed by the winds are probably the most important in this action, as the tides are very small, varying in rise and fall from .8 foot (neap) and 1.8 feet (spring) (average, 1.3 feet,) to extreme tides, with a rise and fall of over 3 feet, produced occasionally by severe gales from particular directions.

Easterly and westerly winds, by producing currents through the sound across the river-currents, probably produce the greatest amount of damage in diminishing the depth of water on the bar.

An examination of the bar and information furnished from various sources coincided in showing it to be composed of a crust of hard sand about one foot in thickness, with a substratum of soft mud of considerable depth.

The depth of water on this bar has varied somewhat from year to year, but the change has been comparatively slight of late years.

There is no doubt that it can be opened or improved; in fact, it has already been once done, according to the testimony of several persons, and especially of Samuel Benezet, esq., for several years a resident of Apalachicola, but now living in North Carolina, and from whom the following facts were principally obtained:

The bar was cut through by a dredge-boat owned by Nathaniel Griswold, of New York, in 1838, a length of 4,000 feet, (width not known,) and to a depth of 10 feet, about, and the cut was used by vessels. The design was to make the width 120 feet. In February, 1839, the channel was still in use. The total cost of that work I could not ascertain, but think it was about $30,000. A lack of funds led to making a sharp turn in the line of excavation originally projected, in order to reach deep water as quickly as possible, and this bend, the selection of an improper place for the deposit of the materials excavated, (from which it was washed back into the cut,) and the lodging of the hull of a brig, which was burned in the channel, on the bank, are assigned as reasons for the cut filling up.

The channel remained open, however, through the seasons of 1839-'40 and 1840-'41. In the spring of 1841 complaints began to be made of the filling up of the channel. It was completely closed up by a severe gale in September, 1841, leaving a depth of only about five feet. Crooked Channel—a channel to the eastward of the one in question—was then used for several years, the straight channel in the meanwhile filling up to about 4 feet, and then deepening to about 6 feet, till about 1850-'52, it was again used, and has been used ever since, its depth varying from 5½ feet to 7 feet, supposed at high water, which is about what it is now. If this bar was once opened, the little change indicated on it at present from year to year would seem to indicate it could be kept open at a slight cost per year.

In regard to the best means of improving the river at its mouth, I should recommend the dredging of a channel through the bar, from the 11-foot curve on the inside to the same curve on the outside, by the shortest line from deep water to deep water, which is also the line of deepest water, or the natural channel, 100 feet wide and 11 feet deep, the width to be afterward increased, if found proper from the success of the first cutting, to 200 feet.

The cost of the improvement would be about as follows:

A channel, to allow vessels drawing 11 feet of water to pass up to the city, 100 feet wide, would require the excavation of about 200,000 cubic yards of sand and mud, which, at fifty cents per cubic yard, would cost about $100,000.

For a channel, same depth and 200 feet wide, about 370,000 cubic yards of excavation, at fifty cents per cubic yard, would cost about $185,000.

The next improvement suggested would be to open a channel through to East Pass, thus opening the navigation of the sound its entire length, and saving the long detour which vessels from the eastward would have to make going around to West Pass.

A preliminary examination in relation to this improvement, and also of New Inlet, was made, but the survey was completed after my return, and the result is embodied in the report of Mr. C. F. Trill, submitted herewith.

Accompanying are tracings of complete maps, showing in detail the various points examined and surveyed for improvement, and a general map showing the bearing of the various points to each other.

I am, very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers, United States Army.

Colonel J. H. SIMPSON,
Corps of Engineers, United States Army, Mobile, Alabama.

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REPORT OF MR. C. F. TRILL, CIVIL ENGINEER, ON THE IMPROVEMENT OF APALACHICOLA BAY, FLORIDA.

MOBILE, ALABAMA, *September* 1, 1871.

I have the honor to submit the following report on the part of the survey and examination of the mouth of the Aplachicola River which was made by me in charge, comprising the projected channel-route though the eastern part Apalachicola Bay, from the upper anchorage to the East Pass, and the examination of New Inlet Pass.

As no United States Coast Survey map of the eastern portion of Apalachicola Bay was at the time in existence, the selection of the best places for crossing the different shoals required a very extensive and careful reconnaissance of the whole east bay, which consumed considerable time. The current observations originally intended, and very important, could not be made on account of the want of reliable meters as well as of time, and on account of the continual rough weather in the advanced season. The fact that the distances between the soundings in sections I A, I B, and III, (the latter being the most irregular formation of all,) are very large, the incomplete condition of the work at New Inlet, and the want of complete current and discharge observations in river and bay, which are an absolutely indispensable base for the construction of all dikes and side works, as also for determining the proportions of the channels themselves, show that the work cannot be considered completed.

I therefore suggest the following as necessary:

1st. A completion of the survey in sections I A, I B, and especially I I I, at New Inlet, and in the gulf next to New Inlet; an examination in regard to a prolongation of the straight channel, with a depth of 13 feet to the 13-foot hole; an examination of Higgins Shoal and West Pass Bar, and especially river and tide current, and discharge observations: 1st. In Apalachicola River, above Pinhooks Point; 2d. In Florida River, (outlet of Lake Weinico;) 3d. In Little Saint Mark's River, (second month of Apalachicola River;) 4th. In the Crooked Channel; 5th. On the bar and in the eastern sections; 6th. At New Inlet; 7th. On West Pass Bar; 8th. Some observations showing the direction and the dividing of the current to east and west in the middle part of the bay. Finally, I should recommend experimental borings in different parts of the bay, and especially at New Inlet. The current and tide observations, to obtain true reductions, would have to be continued for twelve months. As, if an appropriation for the dredging should be made, an engineer and assistant, with sloop and party, would have to be stationed in Apalachicola, they could make all the observations in the bay; and for those in the river-branches above an extra sum of about $2,500 would be sufficient, to which will have to be added the purchase of the necessary meters, &c., and of six or seven self-recording gauges, the price of which I do not know.

The following shows the result of the work done in this season:

THE EASTERN CHANNEL ROUTE.

As a general description of the bay has already been given by Captain Damrell, I shall say little about this subject. The three shoals between the upper anchorage and the East Pass are the Norman Bar, the Bulk-head, and the Lumps. The Norman Bar and the Bulk-head have, in my opinion, been formed by the meeting of the two tide-currents from East and West Passes.

If this opinion is correct, which can only be ascertained by current observations, the cuts in these places will have a tendency to fill up again rapidly.

The Norman Bar is not a very great obstacle, having at present, at its best place, 7.5 feet on its crest at mean low tide. The proposed cut follows the line of the natural current. Maximum length of cut 5,575 feet; maximum depth 2.5 feet; excavation, 51,000 cubic yards.

The Bulk-head shows three different places which might be selected for crossing.

The first, on the south side, which I deem preferable to all others, lies in the straight line from stake I to the turn-stake No. 7, (Sheet No. 3,) in the same line with the best crossing of Norman Bar, also almost parallel to the direction of the natural current. Maximum length of cut, 6,000 feet; maximum depth, 6.25 feet; excavation, 175,000 cubic yards.

The northern passage over Bulk-head shows two distinct bars, divided by a deep hole, with 16 feet water between.

The western portion (section II A) is unimportant, being short, and, on the shoalest place, covered by 8 feet water at mean low tide. The eastern portion (section II B) resembles in its profile very much section II. For section II A the maximum length of cutting is 2,350 feet; maximum depth of cut, 2 feet; excavation, 24,000 cubic yards. In section II B, 6,800 feet, 6.25 feet, and 172,000 cubic yards. Total, 196,000 cubic yards.

The objections against this line are: 1st. More excavation than in section II. 2d. The necessity of three turns, one of which, at stake 5 B, is very sharp. 3d. The natural current crosses it at nearly right angles; therefore, if cut, eddies are liable to

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form, and the cut would have a tendency to fill up rapidly. 4th. The passage from stake 6 B to stake 8 B is not perfectly clear; several lumps with only 9.5 feet water have to be crossed, though consisting of such soft mud that steamers could, at low tide, actually pass through the same and clear the way themselves.

The third pass over Bulk-head lies in the middle, between the two mentioned, from the point of the 10-foot curve, in section II A, to the deep hole east of Bulk-head. It is clear of the 5-foot curve, but the 10-foot curves on both sides are much farther apart and the shoal spreads over a longer distance. A line of soundings run over it convinced me that its profile is, and its excavation would be, no less than the one of either of the above sections. Besides, sharp turns would have to be made at its deflection from section II A, and around the very hard oyster-bar, with only 5.5 feet water in its eastern part. Also, the passage from there to stake No. 7 is not straight and not perfectly clear. I think this line inferior to both the above; yet a closer examination of the same might be made.

The third shoal, commonly called the Lumps, is not as remarkable for its shoalness as for its extent, it having nearly twice the length of section I or II. There are two channels here. The one nearly follows the line of section III; the second, the deeper, narrower, and more irregular one, lies to the southward of the first, both having a very shoal flat between. Competent pilots, living in Apalachicola for twenty years, assured me that this latter channel was gradually filling up, and a few jetties, erected there in proper position, would soon cause the filling of it to the level of the flat, and the preserving of the proposed cut, which runs straight from the deep water, north of the oyster-bar at stake 9, to stake 11. Maximum length of cut, 9,400 feet; maximum depth, 4 feet; excavation, 140,000 cubic yards.

As only few places between these three shoals have more than 10 feet depth at mean low water, and therefore dredging to a greater depth than that would increase the amount in some sections almost to double what it is for 10 feet, the excavations have been calculated for this depth only. Thus we have, selecting section II as the most proper crossing of Bulk-head, the excavation for the eastern route:

	Cubic yards.
Section I	51,000
Section II	175,000
Section III	140,000
Total	366,000

which is, at the rate of 50 cents per cubic yard, equal, in cost, to $183,000.

As to the nature of the bottom, and the facilities for dredging in Apalachicola Bay, I have to remark that on the blue-clay bank, which forms the proper bed of Apalachicola Bay, rests a soft mud, evidently the deposit of the river, which is found in all places of 9 or 10 feet water, but all the bars are covered with a very hard crust, varying from 1 to 2 feet in thickness, which is a conglomerate of the said mud with very fine sand, and, on the eastern bars, mixed with small shells. As the mud, through which the cuts would have to go, is so exceedingly soft, I allowed nowhere less than 2.1 slope, and do not think that even this will be sufficient everywhere. The deposits of excavation for the bar at the mouth of the river would have to be made behind the dike in Crooked Channel; for sections I and II, in the south end of the deep holes westward of the shoals; for section III, in the crooked channel south of the flat.

NEW INLET.

This pass, formed by a gale in 1837, is very narrow and deep, the greatest depth in it being 21 feet at mean low water. This deep water is divided from the deepest basin in West Bay, known as the 13-foot hole, by the east end of Higgins Flat, over which there is a channel of 4 feet at mean ow water. This channel, however, is so narrow and irregular that it is not fit to be followed by a deep cut; therefore, the shoalest places in the straight cut, proposed on Sheet No. 4, would be covered with only 1.5 feet at mean low water, making thus the maximum cut for a depth of 13 feet 11.5 feet. This depth of 13 feet I have assumed, because the 13-foot hole, a splendid anchorage, about two to two and a half miles long and three-quarters to one mile wide, has this depth. The distance of cutting through the inside shoal at New Inlet is 6,000 feet; excavation, 213,750 cubic yards.

From the deep water in the gulf New Inlet is divided by a little ridge running all along the outside beach of Saint George's Island at a distance of about one-quarter of a mile from the shore. The deepest cut through this ridge is 10 feet; the distance, 2,200 feet; excavation, 65,200 cubic yards. In this section I think a slope of 4.1 necessary. Total excavation at New Inlet for 13 feet, 278,950 cubic yards, $140,000.

Of the breakwaters necessary for keeping the channel there open, I shall speak hereafter.

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THE ADVANTAGES AND DISADVANTAGES OF DIFFERENT ROUTES.

I should not recommend the dredging of the eastern channel route at all. A difference in distance of ten or twenty miles, more or less, is not very important with a ship making a trip of several hundred miles.

The only use for the eastern route I can see would be as a part of the Mississippi and Atlantic Canal, which has been talked of. What I recommend, and what Apalachicola needs, is one channel from the mouth of the river to the Gulf; a prolongation of the river-channel from the Tow-head to the outside beach of Saint George's Island, with the greatest possible depth. It is evident that the shortest line is the best and will cost the least. Take the $183,000 which the eastern route would cost, and apply them to the obtaining of a greater depth in the one channel, and to the proper protection of the same for the future, and you will do more good to the town and its trade than by cutting two or three channels of 10 feet depth, the most of which will be filled up again in four or five years. The best way this one channel can possibly be laid is through New Inlet.

That this route is the shortest is seen by a glance at the map. That it is and will be, for the future, the best, will be shown by the following: The channel to the city is above projected with 11 feet depth. Already, now, the ship-channel in West Bay is insufficient for 11 feet draught. The crest of Higgins Flat, showing on the United States Coast-Survey maps of 1861 11 feet water, has now scarcely 10.5 feet; West Pass Bar, having had at the time mentioned 13 feet at mean low water, has now, according to the unanimous statements of the most competent pilots and captains, only 11.5 feet.

Already an improvement of Higgins Flat is necessary, and in a few years one of West Pass Bar will become equally necessary. There will be two places to be attended to continually; at New Inlet only one.

But should the city of Apalachicola—which is not unlikely—again become a thriving emporium, as she has been, and a deepening of the channel become desirable, the advantage of the New Inlet line would be still more manifest. An increase of the channel-depth of a single foot would, by the way of West Pass, require a continual cut of six miles besides the cut through West Pass Bar. In the 13-foot hole, and at New Inlet, the depth of 13 feet—that is, 2 additional feet—would already be there, and for each additional foot the advantage of New Inlet will increase tenfold. An increase of the depth to 13 feet would, assuming the 11-foot channel to the upper anchorage to be completed, require an additional excavation of—New Inlet, 610,000 cubic yards; West Pass, 930,000 cubic yards. And we will be struck much more by the advantages of the New Inlet line, if we consider the necessity of protective works for the channel and the prospects for its being kept open in future. No dredging ever has been done nor ever will be done at a place where any cross-currents exist that would last forever; more especially so, a cut through river-bars formed by currents.

The absolute necessity of refilling is shown by the law itself by which the first formation of these bars took place. It is evident that such a bar can, by artificial prolongation of the river-banks, be removed out to any desired distance in the sea, but it will always be at the end of the works. How fast this new bar, after each prolongation, will form, and in what distance from the end of the parallels its crest in the mid-channel will be, will chiefly depend upon the velocity of the confined stream in its last section, the proportion in which the profiles increase, and the amount of sediment pushed along by the river, about which items I have, in our case, no *data* whatever.

It is evident that by carrying our side-works into a lesser or greater depth, by letting them terminate either abruptly or gradually, and by giving different shapes to the mouth of our artificial river, and at last by placing the termination of the work either parallel or under a certain angle to the general direction of the tide-current at that place, we can obtain either a very steep, abrupt, and shoal bar, or a more spread and level one. Outside of New Inlet side-works or breakwaters would have to be carried to a considerable depth—30 or 40 feet—to secure a sufficient depth for many years to come. How this termination ought to be arranged I cannot determine now, as I am entirely without any *data* as to discharge, velocities, and directions of currents, &c. As New Inlet is formed in quicksand, the erection of outside parallel piers will be a necessity for keeping a channel open in any case.

The dimensions and cost of the same can only be derived from the depth at which either the blue clay or a sand-bed hard and solid enough for foundation is struck, which can only be ascertained by borings.

I.—*Proposed improvement of Apalachicola Bay.*

Straight channel, 200 by 11	$185,000
Eastern channel	183,000
	368,000
Additional work necessary:	
Shutting off Crooked Channel, dams in river, (regulation of profile,) opposite and immediately above the town	30,000

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Shutting off Saint Mark's River and structures producing the filling of same.	$6,000
	404,000
Addition of 10 per cent. for engineers, sloops, and parties and unforeseen expenses	40,400
Total	444,400

Or, in round sum, $450,000.
Without the Eastern Channel, round sum, $275,000.

II.—*Improvement proposed by me by way of New Inlet.*

Cut of 100 by 11 through the bar	$100,000
Cut of 100 by 11 through New Inlet	70,000
All side-works	200,000
Breakwater at New Inlet, assumed worth	60,000
	430,000
Addition of 10 per cent	43,000
Total	473,000

Or, in round sum, $475,000.

By this system, not only 11 feet, but any depth desired over that, down to the strata of the blue clay, could be obtained and maintained in the channel without further dredging, by merely regulating the profile of the confined stream accordingly. The side-works would by no means be all solid and uninterrupted, but would have to be arranged like the parallels and traverses used to produce fills in river improvements, and such as to admit flood-tide from the sides. Also, their tops would have to be kept in such depth below the water-surface as to allow small craft of 3 or 4 feet draught to sail over them at any time. After a series of years, a prolongation of the breakwater, or the erection of some special structure of small cost, will be sufficient to maintain the required depth in the mouth of the artificial river for generations.

The following plats are furnished:

1. Index map. Scale, $\frac{1}{10000}$.
2. Special maps, on a scale of $\frac{1}{10000}$. The mouth of the river. East Bay. New Inlet.
3. New Inlet. Scale, $\frac{1}{2000}$.
4. Plans of all the sections, $\frac{1}{200}$, with working profiles. The bar in the mouth of the river.

Section I.
Section II.
Section II A.
Section II B.
Section III.

Very respectfully.

C. F. TRILL,
Civil Engineer.

General J. H. SIMPSON,
Colonel of Engineers, United States Army, Mobile, Alabama.

O 3.

IMPROVEMENT OF THE CHATTAHOOCHEE RIVER.

MOBILE, ALABAMA, *March* 25, 1872.

GENERAL: I have the honor to submit the following report on the survey and examination of the Chattahoochee River, and the means of thoroughly and permanently improving the same for the purposes of navigation. Having, on the 14th of September, 1871, received orders to take charge of the survey, I left Mobile the 15th, accompanied by Mr. W. R. Warren, assistant to me, and reached Columbus, Georgia, September 16. At this place at first great difficulties were encountered in having the necessary preparations for the trip made.

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The leisure time I had during this period I spent in two steamboat trips up and down the river, to which I was gallantly invited by A. Fry, esq., captain of the Barnett line. Thus I gathered a great deal of information and knowledge about the nature of the river, which proved to be very time-saving afterward.

The transit-line was finally started October 19, and the work closed at Eufaula wharf, December 10, for the season.

The South, freed from the influence of slavery, and gradually recovering from the effects of the civil war, is rising up to a future which necessarily must far exceed its highest prosperity in former days; and the South decidedly has advantages of climate, soil, and natural wealth, almost yet intact, which few of the Northern and Western States share.

The cotton production, this main branch of southern industry, is again increasing year by year, and though it has not quite reached its former culmination, yet it will soon do so. And since 1865, a thing not known here before, manufacturing has sprung up everywhere throughout the Southern States, in a manner which is most promising, and has, assisted by northern capital, in a comparatively short time, already assumed astonishing dimensions. But there is one great pressure lying on the free development of the South. While the North has, since 1860, never stopped its activity and progress; has received improvement after improvement; while harbors and rivers were improved, ship-canals dug, &c., nothing has been done for the South; its harbors have filled up; its rivers have become wild streams; it has nothing but a few badly-managed railroads, which exert a shameless monopoly, and which, as long as the country is confined to them alone, must, by their tremendous rates, necessarily produce a pressure much felt by trade and industry.

Therefore free, public, natural routes of communication and transportation are the great want in the South.

The country on the Chattahoochee, Flint, and Apalachicola Rivers is one of the most eminent sections of the whole South, milder than the western part, and richer than the prairies of Texas, offering all imaginable advantages to agriculture, manufacturing, and immigration. Along the Chattahoochee and Flint an uninterrupted line of cotton-plantations covers the borders of the rivers, and from the latitude of Bainbridge down, the whole is not, as usually imagined, a miserable swamp, but an immense and inexhaustible forest of the most beautiful pine, cypress, and cedar, offering unlimited advantages to lumber traders; although it is yet an almost unknown country. The cotton-plantations above produce, even those under bad management, never less than one bale, or five hundred pounds, per acre in the average; on Wolfox plantation, near Columbus, sixty bushels of corn have been raised per acre in 1870; the production of sugar-cane is abundant in proportion to its extent; a superfluity of oranges and fruits of all kinds is found; the facilities for raising tobacco, &c., are very great; also I do think that this section of the country would offer great facilities to silk-production. I have noticed the finest mulberry growing spontaneously, and the climate is as suitable for the silk-worm as any one can be.

Finally, there is to be mentioned that in this eminent region large bodies of land, belonging to dissolved companies, the larger part of it having been under cultivation before, are for sale here almost as cheap, and have in several instances to my knowledge been sold even cheaper, than Government land in the West, and I think that the immigrant coming here will find more accommodation and facility and will earn the fruit of his labors at an earlier day than in the prairies of the West.

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And through this promising region flows a large vein of natural communication, needing only little help by the hand of man—the Chattahoochee—which, united with the equal Flint, passes through the richest timber-land of the world down to the bay of Apalachicola.

This route all the trade and traffic of the country once has gone in days not very far back, and it must again follow the same if the necessary facilities are given, as Apalachicola, and not Savannah, is the natural sea-port for Southern Georgia, Southwestern Alabama, and Middle Florida.

The trade of the city of Columbus.—I give here the following statement, for which I am obliged to H. S. Estes, esq., and Captain T. E. Blanchard, of Columbus, showing the trade of the city for 1871:

	Estimated value.
1. Manufacture:	
Cotton factories: Eagle and Phenix Mills	$750,000
Muscogee Mills	200,000
Columbus Mills	250,000
Sash and blind factory	65,000
Palace Flour-Mills	35,000
Columbus Iron Works	300,000
Total	1,600,000
2. Receipt of cotton during the season:	
Seventy-five thousand bales	$6,500,000
3. Sales of merchandise in Columbus for 1871:	
Groceries	$2,079,000
Dry-goods	938,000
Hardware	404,000
Boots and shoes	200,000
Drugs	140,000
Furniture	61,000
Guano	50,000
Crockery	40,000
Total	3,912,000
4. The banking capital estimated at	$200,000
The insurance capital, "Georgia Home"	450,000

H. S. ESTES,
President Board of Trade.
T. E. BLANCHARD,
Alderman.

I also cite a statement given by the Columbus Sun:

COLUMBUS, GEORGIA, *January* 20, 1872.

The value of our river and the necessity of its improvement.—We give the statistics of the cotton trade of our river. In 1865–'66 we have no record of the separate receipts and shipments, but if our memory is aright, Apalachicola received that year 125,000 bales. We think some 30,000 bales must have gone from Columbus.

The following table shows the receipts and shipments for each season:

Year.	Received.	Shipped.
1866–'67	3,090	3,201
1867–'68	7,632	3,226
1868–'69	5,204	8,636
1869–'70	6,046	150
1870–'71	7,495	11
Total	29,467	15,224

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Thus far this season the receipts have been 3,212, thus making 32,619 bales which have been received at Columbus in four and a half seasons by this source, and 15,224 shipping in five.

Now when it is considered that immense supplies are sent down the river in exchange for this cotton, the value of the trade is estimated at hundreds of thousands of dollars. Then, too, Eufaula, Fort Gaines, and Apalachicola get large supplies and large receipts of cotton. We do not overestimate when we think that on our river to the bay are annually transported some 35,000 bales of cotton, and millions of produce.

Eufaula, Alabama.—About the trade of this city I have no statement whatever. It is a thriving business place, but seems to be more of a trading station than a manufacturing town. Of the latter kind of establishments, there are to be mentioned only several saw-mills doing a splendid business; but the amount of traffic done, especially in cotton, must be of considerable value. The following railroads meet at Eufaula:

1. Montgomery and Eufaula Railroad.
2. Branch of the Georgia Southwestern Railroad.
3. Vicksburgh and Brunswick Railroad, (under construction.)

A new railroad is projected to Marianna, Florida; surveys are being made.

Fort Gaines, Georgia.—This is a place of considerable trade, with large receipts of cotton and with a branch of the Georgia Southwestern Railroad.

Bainbridge, Georgia, on the lower Flint, is, next to Columbus, the largest cotton-emporium on the rivers. It receives even more cotton from the Chattahoochee River than Columbus does. I have no exact statement in reference thereto, but competent authorities judge that the amount of cotton annually shipped to Bainbridge, and from there to Savannah, is about 25,000 bales.

Of railroads, there are the Atlantic and Gulf Railroad and the Bainbridge, Cuthbert, and Columbus Railroad under construction.

Neil's Landing, Florida, the river port of Marianna, Florida, and the adjacent country, has to be mentioned as a large cotton place.

Chattahoochee, Florida, at the junction of the Flint and Chattahoochee Rivers, has also become a place of importance, having been lately reached by the Jacksonville and Pensacola Railroad. A prolongation of the same to Marianna, Florida, and westward, is projected.

Apalachicola, Florida.—At last Apalachicola, the natural sea-port for these rivers, cannot be forgotten. Before, during, and immediately after the war, Apalachicola received all the cotton from the Chattahoochee, Flint, Apalachicola, and Tshoupola Rivers, amounting to 175,000 bales a year. In 1865 the receipt was yet 125,000 bales; but since that the trade of that city has gone over to the railroads mentioned above, chiefly for the reason of the bad condition of its harbor, having filled up to 5½ feet at high tide. But yet the receipt of cotton in 1870 was nearly 10,000 bales; and Apalachicola is rising again. The place of the cotton-trade has been taken by the lumber business. There are at present three saw-mills running there, with a capacity of 160,000 feet of lumber per day, at $15 and $20 per thousand. Two more mills will be erected this year, and several more yet are projected. Thus rising in importance itself, Apalachicola must also raise the importance of the river.

At last it is to be mentioned that the New York and New Orleans through freight line, via the Savannah and Georgia Central Railroad, and a second freight line from New York to the upper-river country, via Apalachicola, also a line connected with the Jacksonville and Pensacola Railroad, are doing their business by the way of the Chattahoochee and

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Apalachicola Rivers. As to the amount and value of the goods transported by these lines, I have no statistics. The reasons why the trade on the Chattahoochee River is at present not larger are to be sought in the following: During the war, of course all business was more or less stopped. After the termination of the same, the few boats that had not been burned or otherwise destroyed were old and rotten, and the most of them not fit to run any longer; no money to build new ones was in the hands of the ruined owners then; and if there was, the bad condition of the river, especially the formation of Bryan's Cut-off in the lower Apalachicola River, which actually did for some time stop all communication, and the decay and filling up of the harbor at Apalachicola, the natural sea-port and outlet for the river-trade, did not let the undertaking appear promising enough, and so it came that nearly all the trade changed over to the railroads then springing up, to which it is clinging still. But there is no doubt that if the Chattahoochee is properly improved, and at once, also the bay of Apalachicola corrected, and if eastern capital continues to be invested here, as it has been for the latest years, the river-trade will soon assume larger dimensions than it ever had before, and the traffic will again follow the best and cheapest route. And how great this trade has once already been, and how necessary an improvement of the river is, is shown by nearly two hundred and fifty wrecks on the same.

Surveys made on the Chattahoochee River.—There have already been made several attempts to survey and improve this river. Long before the war—the year I do not know—an appropriation of $300,000 was made by the State of Georgia for improving the same. Among the contractors an individual by the name of Barnett was largely concerned. But the thing seems to have taken a miserable termination. All there was completed was a little dam on Wolfox Bar, put up so awkwardly that the next high water had to break it; the $300,000, however, disappeared, and nothing had been done. Then, again, shortly before the war, an appropriation was made, so I am informed, partially by the Government and partially by the State of Georgia, of $50,000 altogether, for surveying and improving the river. But the parties trusted with the first part must not have been very competent, as it seems they did not understand how to reduce their soundings to the gauge, and they reported "12 feet of water in the channel throughout the whole river." Therefore this will have to be considered the first regular survey of the river made.

General description of the Chattahoochee River.—After tumbling in continual cascades over the rocks, from the "Lovers' Leap" to Columbus, the river becomes navigable immediately below the city, with a low-water discharge of 2,610 cubic feet per second. From there it flows, with a fall of eight inches per mile, in wide curves, in a generally due southward direction. The width of the river at Columbus is 350 feet, too wide for discharge and fall; and the river has in this part formed a series of shoals, with 2 feet water in the channel. Breaking through the solid strata in the Euchee Rapids, the river is obliged to take a turn to S. 70° E., which direction it keeps for the next eight miles. In this part frequent shoals, with half foot more than above, are yet found. At Chimney Bluff, twenty-two miles below Columbus, the river is thrown back to the westward by a high mountain-ridge, and flows off S. 20° W., which general course it keeps straight until it reaches Eufaula. Below Chimney Bluff another set of shoals, called the Race Passes, with an average of 3 feet water in the channel, is found for about four miles. Thirty miles from Columbus the river has to pass

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through another series of strata, and forms the Snake Shoals, which are rapids of a milder nature. From the Snake Shoals down, only a few scattered shoals, with not less than 4 feet in the channel, are occasional, until Cowaga River is reached, which brings an additional discharge of 550 cubic feet per second. Below Cowaga River the Chattahoochee has a larger discharge and less fall. Gravel-shoals are not found any more, and the rock-shoals below Eufaula have 1½ feet more water than those above.

For this reason, and knowing that neither appropriation nor time would allow to finish the survey of the whole river in this season, I confined myself chiefly to the upper part of the same, as the one needing improvement most badly, and made the survey of the same as complete as possible. The elevation of the low-water mark at Columbus bridge, is, according to the levels of the Mobile and Girard Railroad, 101 feet above the Gulf of Mexico. The total fall from Columbus to Eufaula, a distance of sixty-three and a half miles, is 42.30 feet; the average fall in this part nearly uniformly eight inches per mile. The average profile is 300 feet wide, with 2,000 square feet average area. The average discharge in the part which will be most subject to our consideration is 3,000 cubic feet per second. The profile of Euchee Reach comes nearest to the calculated best.

The exact discharges are: At Columbus, 2,610 cubic feet per second: in Euchee Reach, 2,760 cubic feet per second; at Roanoke Island, 3,420 cubic feet per second; at Eufaula, 4,110 cubic feet per second. Mean low water was, by authority of the oldest pilots on the river, assumed equal to the stage of 2 feet on the crest of Wolfox Bar, the shoalest place in the river. Mean low water, 2 feet; yearly mean water, 5 feet; common high water, 15 feet. The lowest water ever known, happening once every two or three years in October and November, is 1.20 feet. The extreme range between lowest and highest water is 65 to 70 feet. This range does not change between Columbus and Eufaula, the profiles having the same proportion as the discharges, and the river being confined between high bluffs all the way.

A great change in the range takes place between Eufaula and Fort Gaines, and in the Apalachicola River the extreme range is only 4 to 5 feet. The bends of the river are very sharp, the smallest radius being about 500 feet. The average angle between two straight reaches is almost 90°. The material of which all the rock on the river consists is a decayed limestone, commonly called "marl," hard enough where constantly covered by water, and exceedingly soft and pulverizing where changing between water and air. It is decidedly too soft for blasting, especially in the flat ledges, yet far too hard for dredging, and the best way I can suggest for its removal is to split it off by means of an instrument similar to the one used in boring artesian wells, only on a large scale. Hard rock is found only in the Beton Rocks, between Euchee Rapids and Chimney Bluff, which are a hard gravel conglomerate. The general slope of all these ledges is to the northward, which seems to be a hint to select, in improving and deepening island chutes, the north branch.

I shall now give special descriptions of the places needing improvement.

I have, according to the dangerousness, &c., grouped these places into three classes: The first-class ones do at low water actually stop the navigation; the second class places are for about one foot better, but yet do need improvement very much; the third-class places are not of much importance, but ought to be improved, if possible, to prevent a

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change of the same to the worse for the future. To the first-class belong Jennie's Island, Abercrombie, Wolfox Bar, Euchee Rapids, Euchee Island, Cody's Rock, Shell Creek Bar, Culpepper's Island, the Snake Shoals, Cowaga Shoal, and Francis Bend. To the second class: Cochicolooche Creek, Ledge No. 4, Upatoi Creek, the shoals above and below Euchee Island, Moore's Rocks, the Beton Rocks, the shoals below Cody's Landing, Chimney Bluff, the Race Passes, (Middle Race Pass might be named among the first class,) and Roanoke Island. To the third class: The bar in Broken Arrow Bend, McIntosh Rocks, the middle grounds above Beton Rocks, and at Hotchichee Creek, Fountenays, Hannahachee, and Hatchachubbee Shoals. I give below three different estimates. The first estimate is calculated for works as complete as they can be erected, securing the thorough regulation of the river for the future; it comprises all three classes of places. As a river steamboat well loaded draws from 4 to 5 feet, and the 1.20-foot stage must not stop the trade, I have assumed a channel 100 feet wide, 5.50 feet deep in the center, for 50 feet width, and 4 feet on the sides at mean low water, thus leaving 4.70 feet center depth at 1.20 stage, as necessary, and have based the estimates for excavation of rock on this.

The latter, however, I have, considering the scarcity of the soundings, for the sake of safegoing, calculated for 6 feet in the center, which will save the addition of the usual per cent. to this part of the approximate estimate.

In the second estimate the depth is assumed with 1 foot less, equals 4.50 feet at mean low water. This depth is already almost insufficient for all requirements of free navigation at the 1.20 stage, (which, as mentioned above, happens in fall or early winter, just the time when the largest business is done.) The third-class places are disregarded in this estimate.

The third estimate, at least, will comply only with the most urgent necessities, a channel-depth of 4 feet at mean low water in the center, at a total width of only 75 feet for the rock, and entirely disregard all permanent, changing, and forming shoals with not less than 4 feet at mean low water at present. It will actually be insufficient, and, except the excavation of the rock, not permanent. Repeated improvements of the river will become necessary after its completion. This estimate is dealing with the first-class places only. I have, for each of these estimates, assumed the following prices as base:

Excavation of marl, per cubic yard	$0 75
Gravel for filling raised for, (per cubic yard)	0 50
Swimming-fascines for foundation-layers, 1 foot diameter, 20 feet long, apiece	0 50
Sink-fascines, gravel-filled, 1 foot diameter, 20 feet long, apiece	0 75
Upright hurdles, basket-work, gravel-filled, 2 feet diameter, 4 to 5 high, apiece	0 60
Full parallel up to 5-foot mark in 2 feet water, per foot	2 50
Full parallel up to 5-foot mark in 3 feet water, per foot	3 00
Full parallel up to 5-foot mark in 4 feet water, per foot	3 50
Full parallel up to 5-foot mark over 4 feet water, per foot	5 00
Jettee or light traverse to 2-foot mark in 2 feet water, per foot	1 25
Jettee or light traverse to 2-foot mark in 4 feet water, per foot	2 00
Jettee or light traverse to 2-foot mark in 5 feet water, per foot	2 80

The cuts mentioned in several instances are not estimated for, as they will be more than covered by the amount of gravel required for filling in the works.

ESTIMATE No. 1.

1. *Cochicoloochee Creek*, (*Sheet No.* 1.)—Although there seems to be a sufficiently wide channel there, the current observations show that rocks No. 1 and No. 2 are dangerous to steamboats descending at great speed.

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Necessary, the removal of rock No. 1 and a part of ledge No. 2. Cost, $150.

2. *Jennie's Island*, (*Sheet No.* 2.)—Here the profile suddenly widens from 300 to over 600 feet. The consequence is that the river splits into two channels and forms the island and shoals. The closing of one chute is required. I should decidedly prefer the right branch. It is already the widest and deepest. It would at once give the best and straightest channel, and requires the least amount of washing out, therefore presenting the least danger of leaving a place below filled up with the shifted material. But, for the reason mentioned above, in the right channel the rock might not be at a sufficient depth below the surface, and the north branch is probably the deepest.

Should borings show that the rock is at the right less than 6 feet below low-water surface, the left branch would have to be chosen. Required works: Guiding parallel up to the 5-foot mark, which I assumed as foreland height, and six full traverses, carried at first to — 0.5 and gradually enhanced as the filling takes place. At the lower end of the island the inclining jettees *a–c*, to produce the settling of the shifted material in the hole behind ledge No. 3, and an attack on the shoal on the north side, in order to lead the current in a more regular curve. On that shoal itself the inclining jettees 7–11, for the entire filling up to the 5-foot mark. After attack and filling has taken place, a half parallel and covering of slope and foot, with sink-fascines, for the protection of the new-made land. Several half jettees and fangs, to produce more rapid filling of the left branch. The removal of a part of Ledge No. 3. Costs, in all, $9,000. Should the left branch have to be chosen, the works would look reversed; also a cut would have to be laid through the island, in the line *a b c*, to produce, with two light temporary jettees, the rapid removal of the same. Cost, the same.

3. *Ledge No.* 4, (*Sheet No.* 2.)—Removal of 7,960 cubic yards of marl. Cost, $6,000.

4. *Abercrombie*, (*Sheet No.* 2.)—Removal of 9,000 cubic yards of marl. The jetties 1–4, to produce the filling of the hole at stake 13 and regulation of the current. A part of the excavated material, which, as there is no deep water here to dump it in, will have to be removed, in any case might be used for roughly throwing up the stone jettees *a–c*, tending to the filling of the false channel there and the regulation of the current. The cost would hardly be increased by this. Cost, in all, $6,900.

5. *Rock Shoal above Wolfox Bar*, (*Sheet No.* 2.)—Removal of 8,660 cubic yards of marl. Cost, $6,100.

6. *Wolfox Bar*, (*Sheet No.* 2.)—A cut through Little Wolfox Island and two light temporary jettees there for rapid washing. The inclining full traverses, 1–12, which will at first have to be erected without the parallel, with temporary prolongations 50 feet farther into the river, to produce more rapid shifting and the storing away of the washed material on the flat. As the washing takes place their heads will sink, always acting in the way required, until the profile shown on Sheet No. 14 is reached, the shape of which they will help to protect. After the filling has taken place up to low-water mark at the heads of the permanent traverses, a full parallel, leaning on to Ledge No. 10, will be required to complete the filling and for protection.

Below the bar we must keep the river confined thus, that the velocity does not allow a sediment up to less than 6 feet depth, and prevent the formation of a middle ground by offering the shifting material a receptacle on the inside of the curve. The jettees, which will also preserve

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the best shape of the profile, must be continued down to Upatoi Creek. Cost, in all, $10,950.

7. *Upatoi Creek*, (*Sheet No.* 3.)—This creek comes into the river under an awkward angle, and is building up a bar in its mouth. The best way would be to lead the creek by the way of *a b c*, and erecting the dividing point *c;* first excavation of soil 8,000 cubic yards. By the dividing point and several jettees the creek can be caused to deposit its sediment in its own old bed; 600 feet fascine protection is required. Cost, in all, $7,400.

The river must be kept confined to some distance below the creek, till jettee No. 24. The depression of the water-surface by the removal of the Euchee Rapids, will yet effect Upatoi Creek with about 0.5 feet.

8. *The bar in Broken Arrow Bend*, (*Sheet No.* 3.)—To guard against a future shifting of the channel and bar, the filling of the left chute to 5-foot mark, by the light jettee 1–7. Cost, $250.

9. *McIntosh Rock*, (*Sheet No.* 3.)—Removal of a part of Ledge No. 11 and Rock No. 11½. Cost, $200.

10. *The Euchee Rapids*, (*Sheet No.* 4.)—Removal of 30,580 cubic yards of marl. Cost, $23,000.

11. *The shoals above Euchee Island*, (*Sheet No.* 5.)—Here the river is too wide for its fall and discharge; a confinement of the same from Euchee Creek down is necessary. Cost, $2,500.

12. *Euchee Island*, (*Sheet No.* 5.)—Shutting of one island-chute. I should prefer the entire removal of the island and a straight channel. Whether this can be done or not without touching the rock-bed will be shown by borings—a preliminary cut through the island and two temporary jettees at the head. At once, erection and gradual enhancing of the traverses in the left chute, with temporary sinking prolongations and the full right parallel. After the new channel is large enough for steamboats, the completion of the left parallel. Cost, in all, $12,400.

13. *The shoals below Euchee Island*, (*Sheet No.* 5.)—Here the river is altogether too wide. A continual confinement till Oswitchee Creek and a filling of the false channels by deep works are required. Cost, $6,600.

14. *Moore's Rocks*, (*Sheet No.* 5.)—Removal of 2,040 cubic yards marl. Cost, $1,550.

15. *The middle ground above Beton Rocks* (*Sheet No.* 6) is produced by the large masses washed out of the deep gully at stake 1030 by every rain. It is continually shifting, and likely to become worse. This must be stopped by filling the false channel to the right and keeping the river confined to a profile at which the current is strong enough to carry away these masses. Cost, $3,500.

16. *The Beton Rocks*, (*Sheet No.* 6.)—Blasting of Rock No. 35 and the ledge running from it to the right shore; also, Rocks Nos. 36, 39, 42, and 43. Cost, $500.

17. *Rock No.* 44 *at Cody's Landing*, (*Sheet No.* 6.)—Removal of the same. Cost, $100.

18. *The shoals below Cody's Landing*, (*Sheet No.* 7.)—The fall of the river is here greater than above or below; therefore the river is entitled to a narrower profile only. As the profile for low water is already as narrow as it can be, we will have chiefly to rely upon the action of mean and higher water, and must erect higher works. Cost, $6,600.

19. *Shell Creek Bar*, (*Sheet No.* 7.)—Built up by Shell Creek. Very strong confinement of the river by a high parallel; traverses 1–8 and jettees opposite, leading out of Shell Creek under a proper angle; first excavation, 2,000 cubic yards, 400 feet fascine protection, and dividing-point *c*. Cost, in all, $7,400.

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20. *Chimney Bluff*, (*Sheet No.* 7.)—I am under the impression that the shoal place at the point of Chimney Bluff comes from a ledge of rocks. In this case, 3,000 cubic yards of marl would have to be removed. Should the rock lie deeper, other works would cost, in any case, not over $2,000.

21, 22, 23. *The Race Passes*, (*Sheet No.* 8.)—Same case as on Cody's Shoals; strong confinement of the river from Upper Race Pass to Big Bend. In Upper and Middle Race Pass parallels would be good. Costs for Upper and Lower Race Pass together, $8,700; for Middle Race Pass, $3,500.

24. *Ledge No.* 45.—Removal of the same. Cost, $100. The middle ground below Big Bend, filling of the false channel by the jettees *a–d*.

25. *Culpepper's Island*, (*Sheet No.* 8.)—The same case as at Jennie's Island. I should decidedly prefer the left branch, being the straightest, widest, and best, requiring the least shifting of material. Full parallel and traverses. Should the rock-bed not allow the use of this branch, and should the right one have to be chosen, reversed works and a preliminary cut through the island *a b c* will have to be made. Cost, in both cases, $8,800.

26. *Shoals below Culpepper's Island.*—Confinement of the river will have to be continued to some distance below Culpepper's Island, where the shifting takes place. Narrowing and filling of the false channel there is desirable; also, at Hotchichee Creek, filling of the false channel and confinement until deep water will be so much more advisable, as the lowering of the water-surface by removal of the Snake Shoals will yet be felt here. Cost, $4,100 for both.

27. *The Snake Shoals*, (*Sheet No.* 9.)—Removal of 34,800 cubic yards of marl. Cost, $26,000.

28. *Fountenay's, Hannahatchee, and Hatchachubbee Shoals*, (*Sheet No.* 10.)—The two first ones are so unimportant that their cost would be covered by the remainder of some other work at Hatchachubbee Creek. The removal of a part of Ledge No. 55 is necessary. Cost, $150.

29. *Roanoke Island*, (*Sheet No.* 11.)—Diversion of the current into two branches and formation of a shoal, which is continually shifting and changing. This must be stopped by shutting one island-chute; it is the right one. Full parallel and traverses. Cost, $7,600.

30. *The Cowaga Shoal*, (*Sheet No.* 12.)—Removal of 1,200 cubic yards of marl out of Ledges Nos. 58 and 59. Cost, $900.

31. *Francis Bend*, (*Sheet No.* 13.)—Removal of 5,780 cubic yards of rock out of Ledges Nos. 60, 61, 62, 63, and 64. Cost, $4,300.

The traverses and jettees ought not to be placed farther than 150 feet apart; also, it will be sufficient to leave one 25-foot opening in the parallels in each field, or even less than that. Exclusively inclining works have been adopted, because most rapid action is required, especially most rapid filling for the protection of the works themselves.

Total amount of Estimate No. 1	$177,[illegible]
Addition of 25 per cent. to the approximate estimate	44,[illegible]
Addition of 10 per cent. for engineering	17,[illegible]
Total appropriation necessary	229,[illegible]

or, in round sum, $240,000.

Estimate No. 2.

1. Cochicoloochee Creek	$[illegible]
2. Jennie's Island	5,[illegible]
3. Ledge No. 4	4,[illegible]
4. Wolfax Bar and shoal above	12,[illegible]

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5. Abercrombie	$5,100
6. Upatoi Creek	2,000
7. The Euchee Rapids	18,000
8. Euchee Shoals and Island	14,800
9. Moore's Rocks	1,000
10. The Beton Rocks and shoals above	1,500
11. Cody's Rock	100
12. The shoals below Cody's Landing	4,200
13. Shell Creek Bar	5,000
14. Chimney Bluff	1,200
15. The Race Passes	7,900
16. Culpepper's Island	6,000
17. Snake Shoals	19,800
18. Roanoke Island	5,200
19. Cowaga Shoal	700
20. Francis Bend	3,000
Total amount of Estimate No. 2	117,450
Addition of 25 per cent. to the approximate	29,350
Addition of 10 per cent. for engineering	11,745
Total appropriation necessary	158,545

or, in round numbers, $160,000.

ESTIMATE NO. 3.

1. Jennie's Island	$3,900
2. Abercombie	3,000
3. Wolfax Shoal and Bar	8,900
4. The Euchee Rapids	14,000
5. Euchee Island	6,000
6. Blasting of Beton and Cody's Rocks	600
7. Shell Creek Bar	3,000
9. Middle Race Pass	2,000
10. Culpepper's Island	4,500
11. Snake Shoals	14,500
12. Cowaga Shoal	500
13. Francis Bend	2,200
Total amount of Estimate No. 3	63,100
Addition of 25 per cent. to the approximate estimate	15,775
Addition of 10 per cent. for engineering	6,310
Total appropriation necessary	85,185

From the rock-shoals from Eufaula to Chattahoochee, Florida, a sum of $120,000 will be sufficient by the scale of Estimate No. 1, and $75,000 by the scale of Estimate No. 2; thus making the cost of improving the whole river—

No. 1	$360,000
No. 2	235,000

I should not recommend any other estimate but No. 1.

It is the only one that really complies with the requirements of unobstructed navigation at all stages of water, and the only one that warrants the efficacy and permanence of the improvements.

Estimate No. 2 is already almost insufficient for the 1.20 stage. The work on the shoals will be less complete, and therefore more liable to breakage, and require more attention and repairing than above.

Estimate No. 3 really complies only with the most pressing wants, removes only the most dangerous places, like Euchee, Wolfax, &c., and those only in an insufficient way. The gravel-shoals will be only incompletely amended, and, on account of proper care not being taken to dispose of the shifted material, and of the whole river not being system-

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atically regulated, new shoals will form, perhaps worse than the present ones.

If Estimate No. 3 should be chosen, and the river have to be kept in its improved state for the future, it would soon be found that this finally will cost more than if Estimate No. 1 had been carried out. In no case ought there to be work done below Estimate No. 2.

There is also to be mentioned at this place Bryan's Cut-off, commonly called the "Slough," in the Lower Apalachicola River, thirty miles above Apalachicola, which is actually the most dangerous place between Eufaula and Apalachicola, and needs improvement no less than the Euchee Rapids. The cut-off was formed in consequence of obstructions erected by the confederates in Virginia Bend.

It is at present 80 to 120 feet wide, extremely rapid and crooked, full of dangerous snags, and becoming worse and more crooked every year. The land on both sides is swampy, with dense timber, nearly constantly overflowed.

The best way of improving this whole place would be a cut of sufficient radius from Cusseta Bend into river Styx, distance about 2,500 feet.

Costs, first cut, 80 feet wide to 5 feet below low water, about 40,000 cubic yards	$16,000
Removal of timber and roots	4,000
Guiding parallels and protection for 8,000 feet	16,000
Future protection necessary	5,000
Structures to produce the filling of the slough and precautions for keeping a sufficient channel in river Styx during the washing out of the cut	5,000
Total	40,000

or, $50,000.

For the accompanying sketch of the neighboring part of the Apalachicola River I am obliged to George Whitesides, esq., captain of the Independent Steamer Line, who presented the same to me. It was made during the war by a confederate military engineer, whose name is not known to the captain. I found it to be very correct. The cut-off and river Styx I have located myself.

The snagging and removal of dangerous wrecks on the river from Columbus to Apalachicola could be covered by $5,000.

Further necessary additions to be made to each of the above estimates. Nothing but the channel excavated in the rock will be perfectly permanent; all the work on the shoals will, if not continually attended to, be damaged in some places, and the river, if left to itself, become worse again after several years. All those works will, therefore, require a continual watching, occasional repairing, and, in every case, a gradual increasing in height, as their action proceeds. The least at which we possibly can put the costs of this surveillance will be 30 per cent. of the original cost of erection.

For Estimate No. 1	$[illegible]
For Estimate No. 2	[illegible]

Further there will have to be added the purchase of two small steam tugs.

I think that if the appropriation should be made, especially if also an appropriation for the improvement of Apalachicola Bay is made, it would be the best way to have a special branch office established, either in Columbus or Apalachicola, for these works.

This office must have a steamboat at their disposition, and such must have the engineer immediately in charge of the upper working division. Nothing could be done without them.

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As the works will last for several years, I think it would be cheaper to buy some steam-tugs than to hire them. After the completion of the works they could be sold or elsewhere used. They need not be large—not over 75 feet long—and should in no case draw anything over 2 feet. They ought to have exceedingly strong engines in proportion, as they must be fast, and also frequently will have to tow heavy barges, working-machines, &c., from one place to another. Snag-beams ought to be put on both. It is likely that tugs of such description could be found on the Ohio River, and could be purchased at second-hand, so that their purchase and adaptation to the purpose would not exceed $15,000 to $20,000 in all. Their running expenses would be about $8,000 a year each.

Thus, considering these additions, we will find that the total appropriations necessary will be—

Estimate No. 1	$464,000
Estimate No. 2	327,000

The amounts required for the completion of the surveys.

The completion of the survey of the Chattahoochee River will require another appropriation of $5,000.

Flint River, a survey of which I should very much recommend, would require $8,000.

Apalachicola River would, on account of the difficult local circumstances, especially from Ricoe's Bluff, Florida, down, and as the work would be frequently interrupted, require $10,000 to $12,000.

I also should recommend a survey of Tshoupola River, another tributary of the Apalachicola, at present navigated from Marianna, Florida, down, with bad rapids, ("Look and Tremble,") $5,000.

A small extra appropriation also might be made for scientific observations on these rivers, to which the engineers in charge of the different divisions easily could attend; also for the purchase of a number of self-recording gauges, as nobody can be found at the different landings along the river who is either willing or competent to keep a gauge continually and accurately, and the varying ranges cannot be established without uninterrupted gauge records. These gauges would require on the upper river a play of at least 20 feet, and their recording-apparatus would have to be well protected against high freshets.

The close connection between the works in Apalachicola Bay and on the Chattahoochee River.

Before closing, I wish to remark that these projected improvements of the Chattahoochee River stand in the closest kind of reference to the work projected in Apalachicola Bay. One done without the other would be almost a failure.

A port of Apalachicola cannot subsist without its commercial feeder, the river; and an improvement of the latter would not be of much benefit without an outlet for the trade of the same at the mouth of it. Therefore, whatever the amount of appropriations made might be, both ought to be equally provided for.

The following maps and plots of this survey are completed:

1. General map of the river, from Columbus to Eufaula. Scale, 1 mile equals 1 inch.

2. Map of the river, on a scale of 1,000 feet to 1 inch. (No copy forwarded.)

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3. Special plans of the places needing improvement, with diagrams of the proposed works. Scale, 200 feet to 1 inch; thirteen sheets.

4. Sheet No. 14; 200 feet equals 1 inch. Results of the velocity and discharge observations, and average profiles of the river in different parts.

5. Cross-sections for each line of located soundings in the bad places on profile paper. (No copy forwarded.)

Respectfully submitted.

C. F. TRILL,
Civil Engineers, Assistant Engineer.

Brevet Brigadier-General J. H. SIMPSON,
Colonel of Engineers, United States Army.

O 4.

SURVEY AT THE MOUTH OF SAINT MARK'S RIVER.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, April 2, 1872.

GENERAL: I have the honor to submit herewith copy of the report of Mr. Joseph Burney, assistant engineer, on the survey at the mouth of Saint Mark's River, from Spanish Hole to Saint Mark's, Florida, authorized by act of Congress approved March 3, 1871.

The difficulties in the way of navigation from the Gulf of Mexico to Saint Mark's, it will be perceived, are not so much the want of sufficient depth of water in the river, it being 9 feet, except near the junction of the Wakulla River, where, for about 200 feet, the river requires deepening 18 inches through limestone rock, as the obstructions caused by oyster-bars, which make the channel very crooked, especially at "Devil's Elbow" and "Duck Trap." The work, therefore, of improving the channel will be, principally, cutting through these oyster-bars, thus making the channel less tortuous.

The cost of thus improving the channel, making the proposed cuts 200 feet wide at bottom, with side slopes of 2½ base to 1 foot vertical and 9 feet deep, Mr. Burney estimates at $40,866.10.

Mr. Burney, however, also states that he sees "no prospect at present of Saint Mark's rising in importance for many years to come." Under these circumstances he does not think it would be of any advantage to the State or district for Congress to grant an appropriation for the improvement of the river, the present channel being more than sufficient to accommodate the very limited business done.

In addition, he reports that it is in contemplation by the Jacksonville, Pensacola and Mobile Railroad Company to extend their road to deep water at Spanish Hole, below which there is a good channel, allowing vessels to come up drawing 9 feet. This would greatly revive the trade of the port and obviate the necessity of anything being done in the channel of the river between that point and Saint Mark's above.

For the above reasons, I do not recommend any appropriation for the improvements of Saint Mark's River.

I forward to-day, by mail, in a separate roll, one tracing of survey and one diagram, showing current observations.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, United States Army.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

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MOBILE, ALABAMA, *March* 12, 1872.

GENERAL: In accordance with your instructions, dated the 26th day of June, 1871, placing me in charge of the survey of Saint Mark's River, Saint Mark's, Florida, immediately after receiving the same, I set out for Saint Mark's, and arrived on the 6th day of July following.

I at once commenced to carry out the first part of your instructions, viz:

"You will first proceed to make an examination, and in this connection you will consult pilots, masters of vessels, merchants, and any other persons who may be acquainted with the nature of the obstructions, and get their views as to the best way to overcome them; you will also obtain all the information possible as to the present commerce of the place, and the probable effect of the improvement on its increase.

"The result of this examination you will transmit as soon as possible, with a rough estimate as to the cost of obtaining a good channel up to Saint Mark's with the same depth of water as is now on the outer bar."

From the above instructions, and the data in my possession, I submit the following report:

Saint Mark's, Florida, is situated on the north bank of the Saint Mark's River, near its junction with the Wakulla River. It is a mere village, and contains the railroad depot and wharf belonging to the Jacksonville, Pensacola and Mobile Railroad Company, which run the cars three times per week between Tallahassee and Saint Mark's. It also contains a post-office, two stores, and about seventy-five inhabitants, white and colored. A deputy collector of customs is stationed here, under the control of the collector of customs, who resides at Cedar Keys, Florida.

There are no kind of manufactories in or near the village, the inhabitants being principally fishermen, who make a very poor living by obtaining fish from the river for the Tallahassee market.

About three miles from Saint Mark's stands the village of Newport, (famous for its sulphur springs,) which was once an enterprising and flourishing place; contained about 1,500 inhabitants, ten or twelve large stores, warehouses, wharves, turpentine distillery, cotton-press, steam, saw, and grist mills, drug-store, &c.

From various causes the trade of the place declined, and now does not contain a single business place whatever, and only twenty-five or thirty inhabitants. Newport was included in the customs district of Saint Mark's.

I have endeavored to obtain the exact amount of imports and exports for the last ten years from official sources, but have not been able to do so. My information is derived from merchants and others who were engaged in the business at that time, and I believe the estimates formed will be found correct.

Previous to January 1, 1861, the commerce of Saint Mark's was quite extensive. Between thirty and forty thousand bales of cotton were annually shipped from the port, in addition to the large quantities of tobacco, tar, pitch, turpentine, resin, beeswax, lumber, hides, and furs. The principal exports were chiefly obtained from Middle Florida and Southern Georgia.

The shipping season usually commenced in September, and ended in May the following year. Trade was principally coastwise, nearly all the vessels clearing for New York; occasionally a vessel would clear for a foreign port, freighted with lumber, but not often.

At that time there were five pilots constantly employed on the river, licensed by the State, who were authorized to charge $3.50 per foot on all vessels drawing 8 feet or under, and $3 per foot on all drawing over 8 feet.

In 1861 the port was closed by blockade, and all business was suspended. The same year the Atlantic and Gulf Railroad, leading from Savannah, Georgia, was completed to Thomasville, an inland town in the southern portion of the same State, thirty-five miles north of Tallahassee, the capital of Florida. This railroad runs through the rich cotton district of Southern Georgia, and along the line of Northern Florida.

The trade of this district formed the principal support of the port of Saint Mark's, the object of the Atlantic and Gulf Railroad Company being to turn this trade from Saint Mark's and carry it to Savannah. But about this time, (1861,) the railroad was seized by the southern military authorities, and used principally by them until destroyed by General Sherman's army in the winter of 1864. In 1865 peace was declared, and the port of Saint Mark's was again open to trade.

The Atlantic and Gulf Railroad, being destroyed, was not in condition to carry off the trade of the district spoken of to Savannah, and for a short time Saint Mark's flourished, exporting, in the season of 1865 and 1866, 17,000 bales of cotton, in the season of 1866 and 1867 about 11,000 bales, and in the season of 1867 and 1868 upward of 4,000 bales. At this time, (March, 1868,) the business portion of Saint Mark's was destroyed by fire, comprising six large warehouses, a wharf over 400 feet long, ice-house, and steam cotton-press. By this time the Atlantic and Gulf Railroad was repaired and in running order, and a connecting link was completed between it and the Jacksonville, Pensacola and Mobile Railroad, running east from Tallahassee to Jacksonville, Florida. This link connected Tallahassee, Florida, and Savannah, Georgia.

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These railroad connections completely carried away all the trade of Saint Mark's and reduced it to its present condition. There is very little shipping business done at the port now. A steamer arrives from New Orleans about twice a month, with an average of five hundred barrels of freight, principally for Middle Florida. The steamers take out no exports, except a little cotton in the winter to New Orleans.

An oyster business is done here in the fall and winter seasons, by sloops and schooners of about five to ten tons burden, and drawing some 3 feet of water, running between Saint Mark's and Apalachicola, bringing oysters in considerable quantities from the latter port.

The future of Saint Mark's as a port remains entirely in the power of the Jacksonsonville, Pensacola and Mobile Railroad Company. Should they take up the railroad between Tallahassee and Saint Mark's, the latter place, as a port, is destroyed. On the other hand, should they extend the railroad to deep water, at Spanish Hole, (as Mr. I. G. Gibbs, chief engineer of the railroad company, informs me the company desire to do,) it would have a very great effect in the revival of the commerce of the port. Should this be done, there would be no necessity to improve the river above the Spanish Hole, and below there is a good channel, which would allow vessels drawing 9 feet of water to come in at low tide.

But upon careful inquiry, I find it is not the policy of the railroad company to improve Saint Mark's. On referring to the maps of the State of Florida, it will be seen, should the bulk of the cotton crop of Middle Florida and Southern Georgia be shipped at Saint Mark's, the company would lose the long land-carriage to Savannah, Georgia, and Jacksonville, Florida, and gain only the short carriage to Saint Mark's.

It will be seen by the following table that the railroad company's charges for carrying cotton, pork, corn, flour, &c., to Saint Mark's are very high as compared with other towns.

For carrying pork, corn, flour, &c.

From Tallahassee to Saint Mark's, twenty-one miles, 25 cents per 100 pounds.

From Tallahassee to Live Oak, sixty-one miles, 33 cents per 100 pounds.

From Tallahassee to Jacksonville, one hundred and sixty-five miles, 45 cents per 100 pounds.

For carrying cotton.

From Tallahassee to Saint Mark's, twenty-four miles, 40 cents per 100 pounds.

From Tallahassee to Jacksonville, one hundred and sixty-five miles, 85 cents per 100 pounds.

The uncertain policy of the railroad company has a most damaging effect upon the prosperity of the port, as no encouragement can be offered for merchants to employ their capital when it can be so readily lost by the removal of the railroad.

After taking a careful review of the information I have obtained respecting the future prospects of Saint Mark's, I believe that, with proper industry and a very large outlay of capital, also carrying the railroad to Spanish Hole, a very large amount of business could be done here.

There is no port on the east having the advantage of a railway communication nearer than Cedar Keys, a distance of ninety miles; on the west, none nearer than Pensacola, a distance of two hundred and eighty miles. Cotton can be carried from here to the market in New York cheaper than by the present route via Savannah.

The cost of carrying cotton by the above route is as follows, viz: From Tallahassee to Jacksonville, per one hundred pounds, 85 cents; and from Jacksonville to Savannah, 32 cents; from Savannah to New York, by sail, 50 cents—making a total cost of $1.65 per hundred pounds.

By the Saint Mark's route, it could be carried from Tallahassee to Saint Mark's for 20 cents; from Saint Mark's to New York for 75 cents. By the Savannah route, it only takes one week to New York; by the Saint Mark's route, one month. Therefore, I allow three weeks' interest on the value of the cotton, at 10 per cent., would equal 10 cents per one hundred pounds; thus bringing cost of Saint Mark's route $1.05, against $1.65, the cost of Savannah route—leaving a balance in favor of Saint Mark's of 60 cents per one hundred pounds. Thus, should Saint Mark's export but half the forty thousand bales of cotton it exported up to 1861, allowing five hundred pounds to the bale, there would be saved to the cotton-growers of the district an annual sum of $60,000.

On the other hand, Saint Mark's has no accommodation at present for the transaction of business; no wharf of importance, the present one being only about 60 by 40 feet; no warehouses or cotton-presses of any description.

The site of the village is upon low, flat, marshy land, covered over with weeds and stagnant water, and the climate extremely unhealthy, it being nearly impossible for a new resident to escape having severe attacks of chills and fever. The coast is also subject to severe gales in the fall months, which sometimes do great damage.

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I see no prospect at present of Saint Mark's rising in importance for many years to come.

Under these circumstances, I do not think it would be of any advantage to the State or district to grant an appropriation for the improvement of the river, the channel being more than sufficient to accommodate the very limited business done on it.

I would, however, recommend that an appropriation of $1,000 be granted for the purpose of properly staking out the channel, which would prove of great value to vessels now using the river.

Passing from the business done on the river to an examination of it for improving the channel, I find the river to run through a low, flat, swampy country, and at high tides the land on both sides is covered for a wide distance with water.

The rise and fall of the tides vary to a great extent, being considerably influenced by the winds; but the ordinary rise and fall I found to be 2 feet 4 inches—high water at the Saint Mark's wharf being about fifty minutes later than opposite Saint Mark's light-house. The fall of the river between these points, ascertained by careful leveling, is 12.9 inches.

Careful soundings of the river show a depth of 9 feet of water in the present channel, with the exception of about 200 feet near the junction with the Wakulla River, and this part of the channel will be required to be deepened about 18 inches through limestone.

On consulting with the pilots, I found they did not complain of the depth of water, but the difficulties met with in avoiding the numerous oyster-bars, which at some portions of the river make the channel exceedingly crooked, especially at the Devil's Elbow and Duck Trap.

The work to improve the channel will be principally cutting through these oyster-bars. I found them to be composed of from 6 to 8 inches of shell, and, for a depth of over 9 feet, mud and sand, which could easily be removed, so that a good channel could be obtained at a very reasonable cost.

To accompany this report I have prepared a plan of the river, drawn to a scale of 1 inch to 500 feet, made entirely from field-notes. Should the work be carried out, I would recommend following the old channel, as shown by plan, and the cut to be made below mouth of Wakulla River, 200 feet wide at bottom, with side slopes of 2½ to 1, and 9 feet deep at mean low water; especial points for improvement being indicated by blue lines.

Vessels drawing 9 feet of water find no difficulty in passing the long bar opposite the light-house, and the Spray Bar, &c., until near the Folly Bar; but here, owing to this bar damming back the water, causing it to run into the channel, thus creating a rapid current on a falling tide, there is some difficulty, though a sufficiency of water.

Passing Folly Bar the channel remains good until arriving at the commencement of the Devil's Elbow, the most dangerous part of the river. At this point the channel turns very suddenly at nearly a right angle, and as vessels endeavor to take advantage of the tide running in the direction they are going, it is difficult, either in ascending or descending, to keep large vessels from drifting on the bar immediately in front.

From this point the channel is exceedingly crooked for a distance of about 2,000 feet; this I propose to straighten as shown by plan.

Passing up the river, the channel remains good until near the entrance of Big Bayou, which would require widening and straightening; the same work would be required in the channel at the Duck Trap; passing on, a good channel is found to the wharf, with the exception of the portion shown near the junction with the Wakulla River.

To make the improvements I have described will require the following amount of work to be done:

32,865 cubic yards dredging sand, mud, and shell, per cubic yard, at 50 cents per yard	$16,432 00
6,573 cubic yards of rock-cutting, per cubic yard, at $3 per yard	19,719 00
Staking out channel	1,000 00
Engineering and contingencies, 10 per cent	3,715 10
	40,866 10

A good channel containing 9 feet of water could be made for the sum of $40,866.10, but, as I stated before, the business done upon the river is not of sufficient importance to appropriate the amount of money required to improve the channel.

I have the honor to remain, very respectfully, your obedient servant,

JOSEPH BURNEY.

Assistant Engineer in charge of Survey.

Brevet Brigadier-General J. H. SIMPSON,

Colonel of Engineers, United States Army, Mobile, Ala.

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O 5.

EXAMINATION OF CHOCTAWHATCHEE RIVER.

UNITED STATES ENGINEER OFFICE.
Mobile, Alabama, April 6, 1872.

GENERAL: I have the honor to submit herewith the report of Mr. Joseph Burney on his examination of Choctawhatchee River, Florida, authorized by act of Congress approved March 3, 1871.

This report shows that vessels drawing less than seven feet of water can pass eastward from Pensacola Bay, through Santa Rosa Sound, for a distance of twenty-six miles. Leaving the Sound, they enter what is commonly called "The Narrows," ten miles in length and from one-fourth to one-half mile wide, in which there is a depth of only from 4 to 5 feet of water. The channel in these narrows is very difficult of navigation from the number of bars to be met, and, on account of their shifting character, is represented as not being susceptible of permanent improvement.

About four miles above the narrows there is a narrow outlet to the Gulf, called "East Pass," having a depth of 5 feet of water on the bar, but which, on account of the violent action of the sea, is very seldom used.

All merchandise intended for ascending the Choctawhatchee River is obliged to be reshipped in barges, propelled by poles, at a small town called Freeport, five miles up Le Grand Bayou. This is a place, at the present time, of considerable importance, on account of having direct communication with New Orleans and Pensacola by means of several schooners, from fifteen to thirty-five tons burden, besides occasional steamboats. It is represented as unsuitable as a depot for transshipment of merchandise on account of its situation, causing the barges running on the river to be poled an unnecessary distance of sixteen miles. This is caused by all land suitable for a depot at the mouth of the river being held by the General Government for the purpose of obtaining timber for the Navy, although, from all the information which could be obtained, the land is pronounced totally unfit for this purpose.

Neither the means nor the time before the winter floods admitting of an accurate survey of the river, in accordance with my instructions, only such an examination of it, from its mouth to Geneva, the present head of navigation, a distance of about one hundred and sixty miles, was made as would be sufficient to predicate estimates for its improvement.

The result of this examination shows that there is available at all times, between the mouth of the river and Geneva, at least 8 feet of water, 3 feet more than can be carried through "the Narrows" at the east end of Santa Rosa Sound, and that the obstructions consists principally of snags, sawyers, overhanging trees, and two wrecks of steamboats. Another source of difficulty arises from the, in some instances, tortuous direction of the channel. The improvements therefore proposed are the removal of the obstructions mentioned and the straightening of the channel in places.

Mr. Burney submits three estimates. The first, amounting to $98,716.80, contemplates a thorough improvement of the river; but the present commerce, in his opinion, will not justify so large an appropriation by Congress.

The second, amounting to $52,291.20, contemplates not so exhaustive an improvement, but one which would be sufficient to meet all present and prospective requirements for many years to come.

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The third estimate, amounting to $34,332, is for the removal of obstructions, which make the navigation of the river both difficult and dangerous, even for the amount of trade done on it at the present time. This amount is about 10 per cent. of the value of the merchandise carried on the river during the past year, and it is believed this extent of improvement will be sufficient for at least five years to come.

As the report shows that the value of the available timber of commerce along the river is estimated from $50,400,000 to $144,000,000, depending upon the distance in which it can be profitably hauled, and the value of the business done during the past year was as much as $284,000, I respectfully recommend an appropriation by Congress of the last amount estimated by Mr. Burney for improving the river, and which the present amount of trade demands, namely, $34,332.

Mr. Burney took repeated cross-sections of the river during his examination, all of which have been mapped, and, with the other information obtained by him, have been placed on file in this office for future reference.

I am, very respectfully, your obedient servant,

J. H. SIMPSON.

Colonel of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,

Chief of Engineers, United States Army, Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, April 6, 1872

GENERAL: In accordance with your instructions, dated the 11th of November, 1871, placing me in charge of the examination and survey of the Choctawhatchee River, Florida, I have the honor to report that, after making the necessary arrangements, myself and assistant, William S. Simpson, left Mobile November 14, 1871, on board the United States light-house schooner Florida, arriving in Pensacola November 17, when I at once commenced to carry out the first part of your instructions, viz: "You will first make an examination, and in this connection you will consult such persons as you can find who may be acquainted with the nature of the obstructions, and get their views as to the best manner of removing them. You will also obtain all the information possible as to the present commerce of the river, and the probable effect of any improvement on its increase; also, the character and resources of the country bordering on it and its tributaries. The result of this examination you will transmit to this office as soon as possible, with an estimate of the cost of such improvements as may be suggested by your examination."

Also, your verbal instructions to obtain all the information possible, without any unnecessary delay, respecting the navigation of Santa Rosa Sound and Choctawhatchee Bay.

From the above instructions and the data in my possession, I submit the following report:

Pensacola is situated on the Pensacola Bay, twelve miles from the Gulf of Mexico, in the county of Escambia, Florida, and is the only port for all exports and imports ascending and descending the Choctawhatchee River. It contains a population of 3,000 inhabitants, and is a thriving commercial town, and naturally interested in any improvements that may be made upon the river. Seven miles down the bay is the town of Warrington, which contains the United States navy-yard, and is situated on one of the finest harbors of the southern coast.

Leaving Pensacola, we pass into the Santa Rosa Sound, which is about twenty-six miles long and two miles wide, and contains a depth of water, as shown by Coast Survey charts, of from 7 to 10 feet. It is divided from the Gulf by a long, narrow island of sand, called Santa Rosa. Leaving the sound, we enter what is commonly called the Narrows, ten miles in length and from one-fourth to one-half mile wide, having a depth of from 4 to 5 feet of water. It is very difficult of navigation, on account of the numerous shifting sand-bars, and is not susceptible of permanent improvement on account of the changing nature of the bottom. Passing on, we enter the

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Choctawhatchee Bay, which is about forty miles long, seven miles wide, and contains a sufficient depth of water for all navigable purposes. About four miles above the Narrows there is a narrow outlet to the Gulf, called East Pass, having a depth of 5 feet of water on the bar; but which, on account of the violent action of the sea, is very seldom used.

All merchandise intended for ascending the Choctawhatchee River is obliged to be reshipped at a small town called Freeport. To arrive at this place, we leave the north side of the bay, about three miles from the mouth of the Choctawhatchee River, and enter Le Grand Bayou, and ascend for a distance of five miles, before arriving at Freeport. This is a small place, containing five stores and about one hundred inhabitants. It is a place at the present time of considerable importance, on account of having direct communication with New Orleans and Pensacola, by means of several schooners from fifteen to thirty-five tons burden, besides occasional steamboats.

Freeport, as a depot for the transshipment of merchandise intended for ascending the Choctawhatchee River, is entirely unsuitable, on account of its situation, causing the barges running on the river to travel an unnecessary distance of sixteen miles. This is caused by all land suitable for a depot at the mouth of the river being held by the General Government, for the purpose of obtaining timber for naval purposes, although, from all the information I could obtain, the land is pronounced to be totally unfit for the purpose for which it is held.

On reaching the river, I determined, with your sanction, as neither the means nor the time were sufficient to make an accurate survey, to commence at the mouth and proceed up the river, taking as many sections of the same, and as full notes of the physical features of the valley, and the difficulties to be overcome, as was possible under the circumstances.

The principal mode of navigation adopted on the Choctawhatchee River is by barges, from ten to fifteen tons burden, drawing from 4 to 5 feet of water, and propelled by poles upward of 30 feet long. the barges carrying from six to ten polemen, and making from two to three miles per hour, generally accomplishing the round trip from Geneva to Freeport and back, a distance of three hundred and forty miles, in from fourteen to fifteen days. A very rapid current is met with in ascending the river, which takes from ten to twelve days to surmount, while in returning the barge drifts with the current in from three to four days from Geneva, the head of navigation, to Freeport.

Entering the river from the bay, I find it has seven mouths, forming a connection with the main river, at a distance from the bay of from seven to ten miles. We carefully examined the mouths, and find the one commonly used, called Mitchell's River, to be the one at present best adapted for commercial purposes. Passing up the river, we find each side of the same composed of low, swampy marshes, covered with a thick undergrowth, interspersed with cypress timber of good quality, easily obtainable, and for which at the present time there is a great demand in the market. This swamp continues, on each side of the river, for a distance of one hundred miles, with occasional small bluffs or hammocks, generally covered with young pine. At a distance from three to four miles from the river is the country known as piny woods, from which could be obtained a large supply of first-class pine lumber.

As shown by plan, the first tributary of any importance is East River, which runs for about twenty miles in the country and again joins the river. This stream traverses a good lumber district partly settled. It is sometimes used by the barges in ascending in preference to the main river, on account of the current not being so swift. The next tributary is Cypress Creek, which is suitable for rafting lumber for a distance of ten miles, of which there is a large supply. The next tributary is Holmes's Creek, a stream of considerable importance, and navigable for fifty miles to Vernon, the county-seat of Washington County, running through a good timber district, partly settled, and from which are exported lumber, cotton, sugar-cane, &c.

There are several small tributaries, as shown by plan, traversing good timber-land from which lumber can be readily obtained.

Up to this point, one hundred miles from the bay, there are very few settlements, and not much land near the river under cultivation. Passing upward, the banks of the river materially change, becoming higher, and covered on each side with pine timber.

At a distance of one hundred and twenty miles up the river is situated Cerro Gordo, better known by the name of Hewitt's Bluff. It is the county-seat of Holmes County, and contains about twenty-five inhabitants, two stores, and two dwelling-houses. It formerly had a court-house, jail, clerk's office, &c., but about twelve months ago they were burned down, and the court is now held in the open woods.

About one hundred and sixty miles from the mouth of the river we arrive at Geneva, in the State of Alabama, the present head of navigation. At this point the Pea River enters the Choctawhatchee River. This stream runs in a northerly direction for about one hundred miles, through the counties of Geneva, Coffee, Dale, Pike, and Barbour, and traverses one of the best timber districts of the State, from which at present nearly all the lumber descending the river is obtained.

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From this point the Choctawhatchee River runs in a northeasterly direction for about sixty miles, passing through the counties of Geneva, Dale, and Henry.

Thirty miles above Geneva, on the Choctawhatchee River, is situated the town of Newton, in the county of Dale, at which place a company has lately been formed with a view to the improvement of the river between the two places.

The town of Geneva was originally situated on the banks of the river, and was a place of considerable importance, containing about 500 inhabitants; but during the year 1861 it was destroyed by a freshet, leaving only three houses of the original number standing. The present town is situated in the forks formed by the Choctawhatchee and Pea Rivers, about three-fourths of a mile from their junction, in the county of Geneva, and is about one hundred miles southeast of Montgomery, and about sixty miles distant from the nearest railway station. It shows signs of considerable vigor and enterprise, contains about two hundred and fifty inhabitants, six stores, courthouse, church, post-office, hotel, &c., nearly all of which have been erected during the last twelve months. Previous to the year 1861, a large tract of country, embracing the counties of Dale, Geneva, Coffee, Barbour, and Henry, in the State of Alabama, and Washington, Walton, and Holmes Counties, in the State of Florida, depended on the river as the only outlet by which their produce could reach the market, but, since the completion of the Mobile and Montgomery Railroad, a large portion of this country, in the State of Alabama, has, by this means, found another outlet for its trade; but should the navigation on the river be improved, owing to the cheapness of water-carriage over rail, I have no doubt that a large portion of this produce, especially cotton, would again use the river as a means of transportation to market.

Owing to the scarcity of railroad facilities in the State of Florida, the counties in this State, mentioned above, are still entirely dependent upon the river as a means of transportation. The following tables will show their area, resources, &c.

State of Florida.

Date.	Counties.	Areas, square miles.	Population.	Taxable wealth.	Acres under cultivation.	Resources.
1870	Washington	1,100	2,302	$279,634	5,563	Lumber, cotton, sugar-cane, produce, &c.
1870	Walton	1,480	3,041	243,611	2,117	
1870	Holmes	720	1,572	157,201	1,050	
	Total	3,300	6,915	680,446	8,730	

State of Alabama.

Date.	Counties.	Acres, square miles.	Population.	Taxable wealth.	Acres under cultivation.	Resources.
1870	Dale		11,239	$757,600	57,729	Lumber, cotton, sugar-cane, produce, &c.
1870	Geneva		2,951	132,602	23,514	
1870	Coffee		6,176	293,569	180,076	
1870	Barbour		29,311	2,392,655	394,845	
1870	Pike		17,423	1,139,181	282,892	
1870	Henry		14,160	942,665	240,939	
	Total		81,260	5,658,272	1,189,995	

Of the resources mentioned above, the lumber is of the greatest value and importance. From information collected from merchants and others engaged in the lumber trade, and from testimony given in the United States courts respecting land-claims, we find that the lowest estimate given is that lumber can be profitably hauled a distance of three and a half miles, and the lowest average per acre throughout the entire water-frontage is five trees per acre, which, when squared and delivered at the mouth of the river, have a value of $9 for each piece of timber. I estimate the water-frontage of

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the Choctawhatchee River and its tributaries, calculating both sides of the river to be, at the lowest estimate, five hundred miles, which would give the following figures:

Length of water-frontage	500
Distance profitable to haul	3½
Number of square miles	1,750
Number of acres per square mile	640
Number of acres available	1,120,000
Trees per acre	5
Trees available	5,600,000
Value of each tree available when delivered at the mouth of the river	$9
Total value of trees	50,400,000

NOTE.—By one of the largest firms now engaged in obtaining lumber from the river this average is made considerably larger, calculating that it is profitable to haul a distance of five miles, and placing the average number of trees at ten per acre. This would give the following figures:

Length of water-frontage	500
Distance profitable to haul	5
Number of square miles	2,500
Number of acres per square mile	640
Number of acres available	1,600,000
Trees per acre	10
Trees available	16,000,000
Value delivered at mouth of the river	$9
Total value of trees	144,000,000

Taking a mean average of the two, which, I think, will form a fair estimate, the total value of timber available would be $97,200,000.

From careful inquiries, I find that the following statistics will show the amount of business done on the river during the past year:

	Value.
Cotton, 600 bales, at $80 per bale	$48,000
Lumber, 14,000 logs, at $9 per log	126,000
Produce descending the river, including corn, sugar-cane, &c	20,000
Value of merchandise ascending the river, estimated at 30 barge-loads, at the value of $3,000 per barge	90,000
Total	284,000

The following table of observations of the thermometer shows the highest and lowest temperature each day during the following dates:

Number.	Date.	Day of week.	Highest.	Lowest.	Number.	Date.	Day of week.	Highest.	Lowest.
	1871.		Deg.	Deg.		1871.		Deg.	Deg.
1	Nov. 20	Monday	56	35	16	Dec. 5	Tuesday	68	[illegible]
2	Nov. 21	Tuesday	56	38	17	Dec. 6	Wednesday	77	[illegible]
3	Nov. 22	Wednesday	54	36	18	Dec. 7	Thursday	94	[illegible]
4	Nov. 23	Thursday	56	36	19	Dec. 8	Friday	84	[illegible]
5	Nov. 24	Friday	60	45	20	Dec. 9	Saturday	93	[illegible]
6	Nov. 25	Saturday	70	60	21	Dec. 10	Sunday	75	[illegible]
7	Nov. 26	Sunday	82	70	22	Dec. 11	Monday	73	
8	Nov. 27	Monday	80	72	23	Dec. 12	Tuesday	76	
9	Nov. 28	Tuesday	82	68	24	Dec. 13	Wednesday	86	[illegible]
10	Nov. 29	Wednesday	70	56	25	Dec. 14	Thursday	66	[illegible]
11	Nov. 30	Thursday	70	40	26	Dec. 15	Friday	62	[illegible]
12	Dec. 1	Friday	58	40	27	Dec. 16	Saturday	76	[illegible]
13	Dec. 2	Saturday	56	40	28	Dec. 17	Sunday	76	[illegible]
14	Dec. 3	Sunday	68	60	29	Dec. 18	Monday	78	[illegible]
15	Dec. 4	Monday	68	38	30	Dec. 19	Tuesday	80	[illegible]

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From the above table it will be seen that the thermometer was the highest on the 13th of December, being 96°; the lowest on December 6, being 24°, or 8° below freezing point; and that the greatest variation in temperature in one day was on the latter date, being a variation of 54°

Carefully reviewing the information obtained, I find that this is comparatively a new country, and what is bringing it into importance is the valuable timber-land through which the river runs.

Pensacola, one of the largest lumber-exporting ports on the southern coast, is greatly interested in the improvement of the Choctawhatchee River, for the reason that the lumber on the banks of the Escambia River, from which it has hitherto drawn its largest supplies, is becoming exhausted, and on account of the long land-carriage and its conseqent increase of expense, is now causing the merchants of that city to turn their attention to the almost inexhaustible and comparatively cheap timber-regions of the Choctawhatchee.

The shipments from this river during the past year are only the commencement of a business that will no doubt be, at no distant date, of very great importance, and which would be greatly facilitated provided that proper improvements were made, so as to allow this lumber to be rafted down the river with less expense, difficulty, and danger.

I also find that one of the greatest obstacles to the commercial improvement of the river is the large area of land on its banks reserved for naval purposes by the General Government; which land, as I have already mentioned, is pronounced unfit for the purpose for which it is held. On account of this reservation, not even a site for a depot for the transshipment of goods, brought by sailing-vessels, can be obtained at its mouth, compelling the reshipment of all goods intended for the river at the village of Freeport; thus causing sixteen miles of extra traveling, both difficult and dangerous for barges built for boating on the river. As this is of great importance to merchants and others interested in the trade of the river, I would respectfully recommend that this subject should be inquired into by the proper authorities, and that the land, of no value for the purpose for which it is held, be thrown upon the market and sold to private parties.

The result of our examination of the Choctawhatchee River, from its mouth to Geneva, the present head of navigation, a distance of about one hundred and sixty miles, shows that there is available, at all times within this distance, at least 8 feet of water, 3 feet more than can be carried through the Narrows at the east end of Santa Rosa Sound, before referred to, and that the obstructions consist principally of snags, sawyers, overhanging trees, wrecks of steamboats. Another source of difficulty arises from the, in some instances, very tortuous direction of the channel. The improvements, therefore, proposed are the removal of the obstructions above specified, and the straightening of the channel.

I submit three estimates for those improvements, depending upon the thoroughness with which they shall be executed.

Estimates of cost of removing the obstructions to navigation in the Choctawhatchee River, from Geneva, Alabama, to the point where the same empties into Choctawhatchee Bay, Florida.

FIRST ESTIMATE.

To 2 snag-boats, tackle and appurtenances complete, at $3,000	$6,000 00
To steam tow-boat and flat-boats attending the same, including expense of working snag-boats 6 months, at $5,000 per month	30,000 00
To cutting and removing overhanging trees on the banks of the river, 60 men, 6 months, at $45 per man per month	16,200 00
To 2 foremen, at $100 each per month, 6 months	1,200 00
To subsistence for 62 men 6 months, at $12 each per month	4,464 00
To removing wrecks of steamers Boston and Eighth of January	2,000 00
To dredging, excavating 40,000 cubic yards, at 50 cents	20,000 00
To excavating 800 cubic yards of solid rock, at $3	2,400 00
	82,264 00
To engineering and contingencies, 20 per cent	16,452 80
Amount	98,716 80

SECOND ESTIMATE.

To 1 snag-boat, tackle and appurtenances complete, at $3,000	$3,000 00
To working the same, including expenses of attending tug-boat and flat-boat 8 months, at $3,000 per month	24,000 00
To cutting and removing overhanging trees from banks of river, 30 men 8 months, at $45 per month per man	10,800 00

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To 1 foreman 8 months, at $100	$800 00
To subsistence for 31 men 8 months, at $12 per month each	2,976 00
To removing wrecks of steamers Boston and Eighth of January	2,000 00
	43,576 00
To engineering and contingencies, 20 per cent	8,715 20
Amount	52,291 20

THIRD ESTIMATE.

To 1 snag-boat, tackle and appurtenances complete	$2,500 00
To working same, including expense of attending tug and flat-boat 5 months, at $3,000 per month	15,000 00
To removing overhanging trees from river-banks, 30 men 5 months, at $45 per month per man	6,750 00
To 1 superintendent 5 months, at $100 per month	500 00
To subsisting 31 men 5 months, at $12 per month per man	1,860 00
To removing wrecks of steamers Boston and Eighth of January	2,000 00
	28,610 00
To engineering and contingencies, 20 per cent	5,722 00
Amount	34,332 00

The first of these estimates contemplates a thorough and complete improvement of the river, but the present commerce of the river is not of sufficient importance to warrant me in recommending to you to ask the General Government to expend so large an amount of money.

The second estimate contemplates not so exhaustive an improvement, but which, if applied, would be sufficient to meet all requirements of the present and prospective trade for many years to come. I leave to your greater experience to say if from the figures, data, and statistics, which I have furnished, you could consider the river of sufficient commercial importance to recommend the Government to appropriate the amount required.

The third estimate is for the removal of obstructions which make the navigation of the river both difficult and dangerous, even for the amount of trade done on it at the present time. The amount called for by the estimate is about 10 per cent. of the value of the merchandise carried on the river during the past year, and I estimate the improvement would be sufficient for all purposes for at least five years to come. This would reduce the percentage on value of goods carried during that time to 2 per cent., which would only be a moderate rate of insurance, and would also naturally tend to the increase of business, especially that which is looked forward to in that district with so much interest, the development of the lumber trade. It is only reasonable to suppose that this increase alone will be many times greater than the amount necessary to pay for the required improvements. I would therefore respectfully recommend that this amount should be expended at as early a date as possible for the present improvement of the river.

In conclusion I would state that my information has been obtained from the most reliable sources, and may be considered correct.

I have also to thank the merchants and others upon the river for their courtesies and hospitality extended toward myself and assistant, and for the facilities afforded us in obtaining our information respecting the commerce of the river.

Respectfully submitted.

JOSEPH BURNEY,
Assistant Engineer in charge of the Examination and Survey of the Choctawhatchee River.

Brevet Brigadier-General J. H. SIMPSON,
Colonel of Engineers, United States Army, Mobile, Alabama.

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O 6.

SURVEY OF TAMPA BAY, FLORIDA.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, March 30, 1872.

GENERAL: I have the honor to forward herewith the report of Mr. Gustave Jaenicke, assistant engineer, on the survey of Tampa Bay, at Tampa, Florida, authorized by act of Congress approved March 3, 1871.

Mr. Jaenicke submits three estimates:

1. For a straight channel, with a width at base of 200 feet and slope of 2.5 feet horizontal to 1 foot vertical, and a uniform depth of 12 feet, mean low tide, estimated cost, $502,121.90.

2. For deepening the present sailing-channel, which he prefers, 200 feet wide at base, 12 feet deep, and slope 2.5 to 1, estimated cost, $549,621.80.

3. For deepening the present sailing-channel, width at base 100 feet, slope, 2.5 to 1, depth, 12 feet, estimated cost, $287,475.65.

In view of the magnitude of the cost of either of these projects, and the liability of the channel in either case to fill up, I would recommend as preferable (for private enterprise, however) the construction of a railroad from the city of Tampa to Passage Point. This point is only about nine miles from Tampa, affording a good site for an *entrepôt*, and what gives it especial value, vessels drawing 18 feet of water can approach it within one-fourth mile. The railroad could be made and stocked for less than $20,000 per mile, or $180,000 for the whole distance, and as the city of Tampa at no distant day will be connected by rail with the Florida railroads to the north of it, I have no doubt that this extension of the roads to Passage Point will naturally follow as a consequence.

For these reasons, and the present limited demands of commerce in this section, I do not recommend any appropriation by Congress for the improvement of the harbor of Tampa.

I forward to-day, by mail, illustrative of Mr. Jaenicke's report, in one roll:

One map of survey of Tampa Bay at Tampa, Florida; one diagram, showing soundings of Tampa Bay lower down; three sheets of current-observations; one diagram, showing railroad scheme.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, November 30, 1871.

GENERAL: On the 26th of June I received the following instructions:

"UNITED STATES ENGINEER OFFICE,
"*Mobile, Alabama, June* 26, 1871.

"SIR: You are hereby placed in charge of the examination and survey of Tampa Bay, Florida, and will proceed to Apalachicola, Florida, where you will hire a sloop and organize a party for the work. You will then proceed to Tampa.

"This examination and survey will probably extend from the town about four miles down the bay. The object of the work is to obtain full and exact information as to what will be required to improve the navigation to the extent authorized by the pres-

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ent or prospective commerce of the port. You will first proceed to make an examination, and in this connection you will consult pilots, masters of vessels, merchants, custom-house officials, and such other persons as may be acquainted with the nature of the obstructions, and get their views as to the best means of overcoming them. You will also obtain all the information possible as to the present commerce of the place and the probable effect of the improvement on its increase. The result of this examination you will transmit to this office as soon as possible, with a rough estimate as to the cost of obtaining a good channel up to the wharves at Tampa, with 12 feet of water at mean low tide.

"Afterward you will proceed to make such a survey of the bay as will enable you to make a map showing the nature and extent of the obstructions and an accurate estimate of the cost of improvement.

"Mr. D. M. Currie is sent with you as an assistant, and will be subject to your orders.

"You will make, every Saturday, a detailed report of operations, showing the progress made during the week ending on that day, and forward as often as the mail and opportunities will allow.

"The amount allotted for the examination and survey still available is $1,938.40, which must cover all expenditures to be made, including the work of the draughtsman in plotting the work when you return to this office, which you will do as soon as the field-work is completed.

"Your pay will be at first $150 per month; if satisfaction is given it will be increased to $200.

"I trust you will exert every ability, and carry on the work accurately, energetically, and economically.

"Very respectfully, your obedient servant,

"A. N. DAMRELL.
"*Captain Engineers, United States Army.*

"Mr. GUSTAVE JAENICKE,
"*Civil Engineer, Mobile, Alabama.*"

In accordance with these instructions, I left Mobile on board light-house tug General Poe, accompanied by my assistant, Mr. D. M. Currie. We arrived at Apalachicola June 29, 10 o'clock a. m., where I organized my surveying-party, hired a sloop, and proceeded with her to Tampa, Florida, stopping on the way at Saint Mark's to leave Mr. Burney, who was to conduct the examination and survey of Saint Mark's River. I arrived at Tampa on the 13th of July, 1871, and began work July 17, 1871.

During the progress of the work tide-observations were taken at intervals of fifteen minutes, and when I was occupied with soundings and borings the readings from the rod were noted at intervals of five minutes. The gauge-clock used for these observations showed true time, and was regulated by meridian altitude of the sun.

I began to take soundings and borings between the two islands lying at the mouth of the river, called the Small and Rabbit Islands, and as this is a very important part of the survey of the bay, I wished immediately to have an idea of the formation and construction of the bottom, and for that purpose I sounded and bored at points 30 feet apart, running a diagonal course in the channel from the south point of the Small Island to the northeast point of Rabbit Island.

I located the extreme points of Rabbit and Small Islands, and ascertained that the former extended about three-fourths of a mile from northeast to southwest, and three-eighths of a mile from northwest to southeast, and was composed of swamps covered with dead mangrove wood, and with sand along the outer edges, and that the latter extended about one-fourth of a mile in length from north to south, and one-eighth of a mile wide from east to west, all swampy, covered with grass and weeds.

After having selected the various stations for triangulations, the beacons, tripods and signals were established. I measured the base-line on the eastern shore of Hillsborough River, extending 2,000 feet north, 7° 50′ east. I then located all the different stations, and began soundings and borings from the upper wharf at Tampa, in Hillsborough River. The soundings were taken in parallel ranges, 100 feet apart, and were carried on successfully when the weather permitted; but, thinking the appropriation would run out before the work was completed, I was obliged to run the ranges a greater distance apart toward the end of the work than at the commencement.

A series of careful tidal observations were made during the whole period of the work combined with current-observations at different stations. The instruments used for these observations were a ship-log and a log-line, divided into feet and fathoms, a 15-second glass, two globes for subsurface currents, a box-gauge, with float, and a 12-feet rod, divided into feet and tenths, a good-going clock, and a sextant to measure the angle of direction.

Thursday, the 17th of August, a northwest gale set in, with constant rain. At 12 o'clock, noon, a hurricane was blowing from west-northwest, the water rising 1.5 feet higher than usual. This hurricane did a great deal of damage, not only on shore, by blowing down fences, trees, telegraph-posts, &c., and overflowing the railroads of the

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interior, but also on the water, by forcing boats from their fastenings and destroying my beacons, tripods, signals, and most of the range-poles. This weather continued until the morning of the 19th, when the gale settled down to a fresh breeze, and I began to repair the damage as quickly as possible. A great deal of time and material was lost by this fearful weather.

The damages done by this hurricane were just repaired when another northeast gale set in, on the 24th of August. Ten o'clock a. m. on the 25th the wind shifted from northwest to southwest, washing and blowing all the established tripods and signals down again, this making the second time the work was interrupted in the most disagreeable manner. Monday, the 28th of August, I was able again to proceed with the work, and carried on the observations from this date to the 15th of October, when I reached deep water, that is, 12 feet mean low water, mid-bay.

During this period the most unfavorable weather was prevailing; strong north winds changed with calms and heavy rains. On the 15th of October I stopped the work, and discharged the sloop and our crew. On the 19th of October I ordered my assistant, Mr. D. M. Currie, back to Mobile to plot the work, and I remained, having received a communication from the office to wait for the light-house schooner Florida, and to return in her to Mobile at the end of the month. I took the work up again, hired the men by the day, and made current-observations during five days, as already mentioned above, from the 27th to the 31st of October. On this day the schooner Florida arrived. I finished up the work and discharged the men, and returned in her to Mobile.

This examination and survey gives the following results:

First. In regard to the soundings, I find that the lower part of this river flows in a bed composed of successive layers of solid limestone rock, mud, sand, and shells in great irregularity, varying from 5 to 6 inches in thickness, and that the least depth of water attained at mean low tide in mid-channel is 4.5 feet. The depth of the river at mean low water between the upper wharf and the Government wharf varies from 9 to 11 feet; from this place to the mouth of the river it decreases again, and the present sailing-channel has an average depth of 5 feet till it reaches the quarantine-pole, where there is 4.5 feet at mean low water; from here to the middle of the bay the depth gradually increases to 12 feet at mean low tide. The bottom of the present sailing-channel is composed of a soft, movable mud, into which a person can, without any exertion, push a pole from 10 to 12 feet.

The greatest velocity of ebb-tide is 2.9 miles per hour, and for flood-tide 1.4 miles per hour. The surface-currents depend a great deal on the wind; when northerly winds are blowing there is very little flood-current. At flood-tide I found the maximum velocity at a depth of 6 feet, being 30 feet in fifteen seconds, equal to 1.4 miles per hour. At ebb-tide I found the maximum velocity on the surface 64 feet in fifteen seconds, equal to 2 9 miles per hour; the accompanying diagram will show it. Often I observed a sudden slacking of the water in the bay when the wind was shifting around, and I presume that during these stands, sediments are settling down, forming those banks in the upper part of the bay.

The ebb-current at the surface runs down sometimes two or three hours longer than regular tidal time would permit, while a slow flood-current is running up at the bottom.

The rise and fall varies much; its average is 2.5 feet in summer-time, when southerly winds are prevailing; in winter-time it ought to be less, because the northerly winds force the water out of the bay.

By this examination and survey I find, secondly, that there are two ways to get to a channel up to the wharves of Tampa, as the accompanying estimate will show.

The first one I would recommend is to use the present sailing-channel, which runs in a crooked way along the western shore, with an average depth of 5 feet, to the quarantine-pole, and from there the depth increases, running in a curve toward the western shore, moving out again, in a southeastern direction, until it reaches deep water.

The second one would run from the 12-foot water point in a straight line, between the two islands, with very little curve, up to the wharves of Tampa.

The present sailing-channel has, throughout, a soft, muddy bed, and a short distance only is to be cut through a sandy bottom, while the proposed straight channel would be cut through sand for a distance of 15,500 feet.

Considering the ebb-current to be the stronger, it would keep both channels open if a dike or bulk-head should be built from the small islands to the eastern bank of Hillsborough River, and another from Oyster Bar to the western shore. In this case the current would be increased on account of the quantity and pressure of the water.

The Small Island lies like a breakwater at the mouth of the river, and splits the current into two branches—one running south, along the western shore, the other turning to the north, and flowing along the eastern shore of the bay. Vessels drawing 12 feet of water can always run up behind Rabbit Island and find a good anchorage.

The entrance to Manatee River is difficult to find. There ought to be a large beacon placed at its mouth.

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It would also be of great importance to the coasting trade if a beacon-light be established at Gadsden Point, to guide vessels coming up Egmont Key Channel at night.

Whether these improvements be carried out or not, the present sailing-channel should be staked or marked out in some way.

Three estimates are submitted: one for a straight channel with a width at base of 200 feet, and two for deepening the present sailing-channel, one with a width at base of 200 feet, and one of 100 feet; all with a slope of 2.5 feet horizontal to 1 foot perpendicular, and a uniform depth of 12 feet mean low tide.

Estimate of cost for the straight channel, width at base 200 feet, slope 2.5 feet to 1 foot, depth 12 feet.

846,573 cubic yards of material to be removed, at 50 cents	$423,286 50
8,396 cubic yards of rock to be removed, at $3	25,188 00
800 linear feet of piling and planking for jettees, at $10	8,000 00
Contingencies and engineering, 10 per cent	45,647 40
	502,121 90

Estimate of cost for deepening the present sailing-channel, width at base 200 feet, slope 2.5 feet to 1 foot, depth 12 feet.

938,991 cubic yards of material to be removed, at 50 cents	$469,495 50
8,396 cubic yards of rock to be removed, at $3	25,188 00
500 linear feet of piling and planking for jettees, at $10	5,000 00
Contingencies and engineering, 10 per cent	49,938 30
	549,621 80

Estimate of cost of deepening the present sailing-channel, width at base 100 feet, slope 2.5 feet to 1 foot, depth 12 feet.

489,495 cubic yards of material to be removed, at 50 cents	$243,747 50
4,198 cubic yards of rock to be removed, at $3	12,594 00
500 linear feet of piling and planking for jettees, at $10	5,000 00
Contingencies and engineering, 10 per cent	26,134 15
	287,475 65

After my arrival at Tampa, on the 15th of July, I endeavored to make myself acquainted with the commercial and mercantile affairs of the place. I submit the following report, based on researches supported by the opinions of the most prominent business men of the place.

Tampa, situated on the eastern bank of Hillsborough River, is a place of about one thousand inhabitants, white and colored, rapidly increasing by settlers from the North. It has a few Government buildings, situated on a fine, well-cultivated spot of land, surrounded by live-oak trees, called Fort Brooks, or more generally known as the Garrison, in charge of an agent of the United States Quartermaster Department, and also occupied by a custom-house officer.

The soil is sandy, but very productive; sweet potatoes, cotton, sugar-cane, oranges and all kinds of tropical fruits are advantageously cultivated. Cypress, cedar, oak and pine grow abundantly; cattle, hogs, sheep, chickens, &c., are extensively raised; hides, deer and otter skins, bees-wax, sugar, and sirup, are exported.

There is one saw-mill and cedar-pencil mill, turning out daily lumber and cedar-pencil boards, which are shipped to Europe.

The annual exports and imports of Tampa are about sixty thousand bales of different kinds of merchandise. In connection with the above statement of exports, obtained from the most reliable persons in Tampa, I give the statements of other individuals as to the shipments of cattle made from this section of the country, and passing through the waters of the bay to foreign ports.

There are from twelve to eighteen thousand head of cattle shipped from this port, and a greater part of the value accruing from these shipments returns to this port in the shape of merchandise, consisting of groceries, dry-goods, hardware, &c., to be disposed of in the interior. The fishing trade is carried on to a great extent, and a good business is done by traders in oysters.

In Tampa there are about eighteen stores dealing and exchanging their goods for the produce of the country around.

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There is not much money in circulation; business is done on the credit system.

Besides these stores there are one newspaper-printing establishment, a blacksmith, a tinsmith, harness-maker, and two carpenters, all white; the laborers are all colored men.

At present Tampa is isolated; there is no railroad communication with the North, and only small coasters maintain the trade between this place and the ports of the Gulf. Notwithstanding this, there is a considerable business done.

A small steamer runs between Tampa and Cedar Keys, connecting weekly with the mail-boat for New Orleans, touching at Manatee River and Clear Water Harbor, carrying the United States mail.

In relation to the mails, there is an overland mail from the North to this place twice a week, arriving Monday and Saturday, leaving Sunday and Wednesday.

In the immediate vicinity of Tampa there are some very fine sulphur-springs, and if communication were opened by water or land, they would attract visitors from all parts of the country, and would be a source of considerable profit to the town and surrounding country.

There is a very large extent of country surrounding Tampa which is extremely fertile, having the finest climate in the world, but which is sparsely populated, with all the advantages necessary to build a country, provided the natural advantages are improved.

The present contemplated improvements will, in the opinion of business men of this place, increase the imports and exports at least 100 per cent.

If Tampa is connected with the North by rail, and the proposed improvements are made, the place will no doubt rapidly improve; it will be brought in connection with all the ports in the Gulf by lines of steamers. Goods can then be carried by steamer to Tampa, and from there sent North by rail, avoiding the dangerous carriage around Key West.

Respectfully submitted.

GUSTAVE JAENICKE,
Assistant Engineer in charge.

Brevet Brigadier-General J. H. SIMPSON,
Colonel of Engineers, United States Army.

APPENDIX P.

ANNUAL REPORT OF MAJOR Q. A. GILLMORE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

P 1.

IMPROVEMENT OF SHIP-CHANNEL, CHARLESTON HARBOR, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
New York, August 28, 1872.

GENERAL: I have the honor to submit the following report of the operations carried on for the improvement of the ship-channel in Charleston Harbor, South Carolina, during the past fiscal year with the $13,000 appropriated by the act of March 3, 1871, and the operations contemplated during the present and coming fiscal years. Under the act approved June 10, 1872, $38,700 was appropriated for this object.

On the 31st day of October, 1871, a contract was entered into with Mr. Benjamin Maillefert for the removal of the five following named and described wrecks for the sum of $10,800, and the proceeds of the wrecks, viz:

The Palmetto State, an iron-clad gun-boat, sunk in the mouth of Town Creek, just above the city, in 1865.

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The Charleston and Chicora, two wrecks near each other, in Cooper River, below Drum Island, off Marshall's wharf.

The Beatrice and her companion, two wrecks near the inner mouth of Beach Channel of the north side of Drunken Dick Shoal.

At the close of the fiscal year the four wrecks first named had been entirely removed in accordance with the terms of the contract, and since that date the companion of the Beatrice has also been removed, and the contract completed. Over the positions occupied by the Palmetto State, Charleston, and Chicora, there is now an unobstructed depth of 12 feet at mean low-water, as required. The Beatrice and her companion were taken out to a low-water depth of 15 feet, in fulfillment of the contract, but the sand has since accumulated upon the sites, and changes are constantly going on there, giving a variable depth of 9½ to 11 feet at mean low water. The position requires some dredging.

On the 15th day of April, 1872, a contract was entered into with Mr. Benjamin Maillefert for the removal, to a depth of 25 feet, mean low water, of the wreck of the single-turreted monitor, Patapsco, sunk in 29 feet of water near Fort Sumter, the contractor to retain the proceeds of the wreck as compensation. At the close of the fiscal year the work had so far progressed as to give an unobstructed depth of 19 feet over the wreck at mean low water. At the present date the work under contract is nearly completed.

PROJECT FOR CONTINUING THE WORK.

After paying for the removal of the wrecks under existing contracts, there will remain available for this work, from the two appropriations last made, the sum of $39,441, which it is proposed to expend substantially as follows, viz:

1. In removing a wreck near Fort Sumter, to a depth of 7 feet, mean low water, $1,200.
2. In removing wreck of monitor Weehawken, sunk in main channel abreast of Morris Island, to a depth of 20 feet, mean low water, $12,000.
3. In removing wreck of wooden gun-boat Housatonic, sunk outside main bar in the track of northern-bound vessels, to a depth of 20 feet, mean low water, $10,000.
4. In dredging Beach Channel to a depth of 15 feet, and a width of 275 feet, mean low water, and dredging in the positions formerly occupied by the wrecks of the Beatrice and her companion, $10,000.
5. In removing 125 linear feet from the end of Bowman Jettee, and the remains of a contiguous wreck, to a depth of 20 feet, mean low water, $8,000.

It is contemplated to do all the work by contract except the dredging in Beach Channel, which will be undertaken by the chartered dredge-boat, now at work on the bar at the mouth of the Saint John's River, Florida.

Should the amount available ($39,441) be insufficient to complete all the work above designated, it is proposed to omit or postpone the removal of the wreck near Fort Sumter, and, if necessary, to reduce both the amount of dredging in Beach Channel, and the length to be removed from the end of Bowman Jettee, in which case the appropriation of an additional amount, sufficient to secure the execution of the foregoing projects, will be requested.

I shall be able to determine this question early in September proximo, in ample time, it is thought, for any new estimate which it may be-

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come necessary to make, to be embodied in the annual estimate of the Chief of Engineers.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major of Engineers, Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

P 2.

IMPROVEMENT OF SAVANNAH HARBOR AND RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, August 28, 1872.

GENERAL: I have the honor to report that nothing was done toward the improvement of Savannah Harbor and River Georgia, during the last fiscal year, as the amount appropriated for that purpose, $50,000, was not available until the 10th day of June, 1872.

During the present and coming fiscal years it is contemplated to commence and prosecute these improvements substantially as follows, viz:

1. In removing one crib, sunk as an obstruction in the channel below Fort Jackson, estimated to cost $1,500.
2. In removing nine cribs sunk in the North Channel, opposite the upper end of Elba Island, estimated to cost $10,125.
3. In removing one wooden wreck sunk in the North Channel, opposite the upper end of Elba Island, estimated to cost $1,250.
4. In dredging on the sites of the cribs and wrecks removed, $1,200.
5. In dredging a channel 125 feet wide at the points, and to the low-water depths mentioned below, viz: On the shoal below Fig Island to a depth of 12½ feet; on the shoal near the head of Elba Island, to the depth of 12½ feet; on the flats abreast of Elba Island, to a depth of 12¼ feet; opposite the lower end of Elba Island, to a depth of 12¼ feet; on the flats northeast of Fort Pulaski, to a depth of 12 feet.

For the continuance of this work in widening and deepening the channel, and in removing the other eleven cribs and three wrecks for which an estimate was submitted in my report dated December 21, 1871, an appropriation is requested for the fiscal year ending June 30, 1874, of $100,000.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major of Engineers, Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

P 3.

SURVEY AND EXAMINATION OF SAVANNAH RIVER AND HARBOR, GEORGIA.

UNITED STATES ENGINEER OFFICE,
New York, December 21, 1871.

GENERAL: I have the honor to state that three charts, compiled from

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the survey and examination of Savannah River, Georgia, made in May last, have this day been forwarded to you by express, viz:

No. 1. The examination of Savannah River and Harbor from the city to Elba Island.

No. 2. The examination of the North Channel, Savannah River, opposite Fort Pulaski.

No. 3. Preliminary sketch of the upper junction of the Savannah and Back Rivers.

There is also sent—

No. 4. Chart of Savannah River and Wassau Sound.

The present depth, at mean low water, on the bar at the mouth of Savannah River, is about 18½ feet, with a mean rise and fall of 7 feet.

The mean rise and fall of tide at the city of Savannah is 6½ feet. Vessels drawing 22 feet of water can cross the bar on the top of the flood without striking when there is considerable sea on, and in calm weather a draught of 23½ feet, as the maximum, can be safely carried over. In spring-tides this may be increased to 24½ feet, and in neap-tides must be limited to 22½ feet. To enable this draught of water to be carried to the city of Savannah on the flood-tide, would require a depth, at mean low water, of 17½ feet.

The present channel is only 10 feet deep at low water in several places and for considerable distances, so that 7½ feet of dredging is necessary to enable the largest vessels that can cross the bar to reach the wharves of the city. The length of the channel in which dredging would have to be made is about eleven miles, or two-thirds of the entire distance from Tybee Roads to the city.

While I do not recommend any expenditures looking to the construction and maintenance of a 17½-foot channel from Tybee Roads to Savannah, I am in favor of conducting the improvements with a view to the ultimate achievement of a practicable 15-foot low-water channel, limiting the dredging at first to a depth of 12½ feet mean low water on the shoals near the city, and 12 feet at Fort Pulaski. Below the city the width of the channel may be 250 feet.

The work which is required to be done may be briefly enumerated as follows:

1. The removal of obstructions.

The obstructions consist of cribs and wrecks placed in the water-way by the State and Confederate State authorities during the late war. Those requiring removal are as follows:

Seven cribs, marked *a* on sheet No. 1, in south channel at head of Elba Island, and dredging on the site	$8,000
Thirteen cribs, marked *b* on sheet No. 1, in north channel at head of Elba Island, and dredging on site	14,000
Four wrecks in north channel at head of Elba Island	5,000
One crib, near and below Fort Jackson, marked *c* on sheet No. 1	1,500
Total for removing obstructions	28,500

My assistant, Captain William Ludlow, Corps of Engineers, in his report recommends the removal of the wreck of the ram Georgia, abreast of Fort Jackson, at an estimate cost of $10,000, and six cribs, in addition to those above named, at an estimated aggregated cost of over $6,000. I have omitted them from my estimate for the reason that their removal can, in my judgment, be wisely postponed, and the money more judiciously expended in dredging at those points upon the river where it is most required.

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2. DREDGING.

	Cubic yards.
South side of Garden Bank, opposite the city, so as to give a channel 400 feet wide, and 12½ feet deep, at mean low tide	72,500
On shoal below Fig Island, a channel 250 feet wide, and 12½ feet deep at mean low water	37,500
On shoal above the piles marked *b*, sheet No. 1, a channel 250 feet wide, and 12½ feet deep at mean low water	13,500
On flats between Elba and Jones Island Channel, a channel 250 feet wide, and 12½ feet deep at mean low water	100,000
Flats northeast of Fort Pulaski, channel 250 feet wide, and 12 feet deep at mean low water	27,000
	250,500

The channel thus formed should be widened and deepened from time to time as the commerce of the place increases, and such arrangements made at points where there is a tendency to fill up as may be determined upon when the contingency arises.

I think it scarcely practicable to lay down any unalterable plan for the improvement of a river carrying down so much silt, with such a rapid current as the Savannah.

SUMMARY.

Estimated amount required for removing cribs and wrecks	$28,500
Estimated amount required for dredging 250,500 cubic yards, at 40 cents per yard	100,200
Total	128,700

I recommend the appropriation of this estimated amount in one sum.

The amount of $5,000 heretofore asked for the survey of Back River is deemed sufficient for that purpose. The question of deflecting the water now flowing through Back River into the channel-way in front of the city of Savannah is reserved for study when the necessary survey shall have been made.

The following papers are inclosed herewith:

No. 1. Captain William Ludlow's report.

No. 2. Statement of the imports and exports of the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871. (Received from the collector, but not signed.)

No. 3. Statement showing the quantities of cotton, lumber, &c., shipped from the port of Savannah, Georgia, to ports within the United States, from January 1, 1865, to August 31, 1871. (Received from the collector, but not signed.)

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

UNITED STATES ENGINEER OFFICE,
New York, November 28, 1871.

MAJOR: I have the honor to submit my report on the survey and examination of the Savannah River and Harbor, Georgia. It should be premised that, although sufficient to ascertain the immediate requirements of the case, this examination, owing to the limited appropriation available, is necessarily incomplete, as not affording full

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opportunity to study the larger and more complex problems involved in the thorough and permanent improvement of the river.

More and closer examination, with time to develop all possible information regarding the velocity and direction of currents at particular points, the data in relation to freshets, their highest duration, &c., with other facts not necessary to specify, are required before a plan can be matured which could be presented with entire confidence in its successful results.

I present herewith three sheets, one showing the hydrography in the vicinity of the city of Savannah, the second giving the results of the examination of the channel north of Oyster Bed, opposite Fort Pulaski, and the third being a sketch of the upper junction of the Savannah and Rock Rivers.

Sheet No. 1 gives most of the important information acquired, including, as it does, the piling, crib-work, and wrecks between the city and Elba Islands, known as the "obstructions;" and also the two shoals, one on the lower portion of the city-front, called the "Garden Bank," and the other just below Fig Island, called the "Wrecks."

It is the removal of the "obstructions" and the dredging of these two shoals which are most urgently required, and to effect which the first efforts at improvement should be directed, as giving the greatest and most immediate relief to the navigation of the river.

Sheet No. 2 was made owing to the fact that the city of Savannah had had dredging done at the point examined, and it was desirable to determine the changes effected and the character of the new channel.

Sheet No. 3 is the result of a brief examination into the available resources for increasing the flow of water past the city, with a view of aiding and supplementing the proposed operations of improvement below, and of rendering them as permanent as possible. I add also the statistics of the Savannah custom-house, showing the immense increase of the city in commercial importance since 1865.

Difficulties in the navigation of the Savannah have always existed. It is a turbid stream, flowing swiftly through an alluvial region, subject to freshets at certain seasons of the year, and always carrying large amounts of mud and silt in suspension. The channel is narrow and crooked, and in ascending the sixteen miles from Tybee Roads to the city shoals and flats are encountered at several points, which prevent large vessels from coming up except at particular stages of the tide. They interfere also with loading the ships to their full capacity, and compel them to drop down to points near the ocean to complete their cargoes, thus entailing heavy expenses in lighterage, loss of time, &c., in addition to those incurred by accident from grounding or collision.

It is fortunate that, in considering the needed improvements to navigation, the bar may be omitted from the account, as there is at all times an ample depth of water upon it to meet all requirements. It is to render the capacity of the river between the city and the sea equal to that of the bar that gives a determinate character to the undertaking, and affords a basis of calculation. The bar has 18 or 19 feet of water upon it at mean low water, and if a draught of 18 feet can be obtained at low tide to the city, the work of permanent improvement may be regarded as satisfactory. At present the draught is limited to 10 feet at several points, and it is not practical at once to attain the ultimate depth. The general considerations affecting its increase will be referred to hereafter.

The city of Savannah has not waited for assistance from other quarters to commence the work of improving its harbor. In March, 1867, they put a dredge-boat, with tender, flats, &c., in operation, and have kept it at work since in dredging the shoals, raising ballasted cribs, sunken wrecks, &c. During this time 280,000 cubic yards of sand, mud, and clay were dredged up in addition to the obstructions removed. The expenditure made by the city for these purposes has been to the amount of $200,000, including the first cost and interest on original and current outlays, being at the rate of $50,000 a year for four years, the average cost of raising a cubic yard of all materials being about 30 cents. The performance of the dredge appears to have been very satisfactory both as to the amount of work done and to its cost.

It is evident, however, that Savannah should not be allowed, unassisted, to carry the burden of the heavy expenditure, and that while other less important points are in course of improvement the large revenues derived by the Government from its commerce entitle it to a share in the distribution of the general aid. The detailed report of the obstructions and the recommendations with regard to them are given as follows:

1. THE REMOVAL OF THE OBSTRUCTIONS.

The cribs were originally constructed, as shown on sheet No. 1, with double platforms, the lower one only loaded sufficiently to sink the crib, while the bulk of the ballasting was placed on the upper platform. This was done with the intention of facilitating their ultimate removal, but in most cases the weight of the stone has crushed down the upper platforms. The timbers and piling were generally fastened horizontally and

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vertically with bolts of one-inch iron, and, as they are still perfectly sound from immersion in fresh water, the work of removing them is difficult. I estimate the average cost at $1,000.

The channel south of Elba Island, called the South Channel, would appear to contain the best water, judging only from the curves at its upper junction. But lower down it shoals to 4 and 5 feet, owing probably to the influence of St. Augustine Creek, which, on the ebb tide, pours a large current nearly against the outflow in the channel, and so retards it. The north channel consequently is the one used by all vessels of any draught, except the Florida boats, which pass through St. Augustine Creek. For this reason it will be necessary to remove only the eight cribs on the south side of the channel, leaving the others to exert their influence in deflecting the flow into the north channel. Estimated cost of removing eight cribs, at $1,000 each, $8,000.

In the north or main channel the cribs should be removed from the northernmost 12-foot curve (red) to the shore of Elba Island, as well as the four vessels which lie near. These vessels, which are of the smaller sort of schooners, are estimated at the same cost as the cribs.

Cost of removing 15 cribs, at $1,000 each	$15,000 00
Cost of removing 4 vessels, at $1,000 each	4,000 00
	19,000 00

This amount is intended to include the dredging of the bottom under the cribs and the removal of the piles at the head of Elba Island.

The other cribs, I think, should be permitted to remain, at least for the present, as I do not believe that any advantage will be gained by allowing the river to distribute its flow over the entire width. The natural bed of the channel is along the bank of Elba Island, and it should be allowed to regain its position before the northerly cribs are taken away. A clear water-way 1,100 feet in width will be ample for navigation. The four cribs south of the 2-fathom line below Fort Jackson should be removed. The others, taken from the line distributed in shoal water below, need not be disturbed. As these four cribs are somewhat larger and heavier than those at Elba Island, and lie in deeper water, I estimate the cost of removal and dredging at $1,200 each, or, for the four, $4,800.

The wreck of the Georgia next claims attention. It lies on the north side of the channel abreast of Fort Jackson and has occasioned accident. It has now 11 feet over it at low water, with a sand-bar forming around it on the north side and west end. The Georgia was an iron-clad ram, about 150 feet in length by 60 feet wide, intended to carry ten guns in casemates covered with a heavy armor of railroad-iron. It has been blasted, but not thoroughly, about eighty tons of iron having been removed. The engines and machinery are still in her, and, including the value of the material probably obtainable, it should not cost more than $10,000 to remove the wreck entirely.

SUMMARY.

Elba Island, north channel, 15 cribs, at $1,000 each	$15,000
Elba Island, north channel, 4 vessels, at $1,000 each	4,000
Elba Island, south channel, 8 cribs, at $1,000 each	8,000
Below Fort Jackson, 4 cribs, at $1,200 each	4,800
Wreck of ram Georgia	10,000
	41,800

The work of removal will probably be most advantageously done by contract, payments being made conditional upon the complete removal of the obstructions, independent of the depth of water. I do not at present recommend any work upon the wrecks lying in shoal water below Fig Island. They are out of the channel, and I think that the cost of their removal, which will be considerable, while the wrecks themselves are not valuable, can better be expended at other points.

2. DREDGING ON THE SHOALS.

The Golden Bank has an average depth of about 8 feet. It should be dredged to a depth of at least 12 feet, and to a distance from the red curve sufficient to give a channel-way of, say, 500 feet. There seems to be no reason to suppose that, the depth having been secured, the river will be unable to maintain it. The number of cubic yards required to be raised is about 100,000. The shoal connecting Fig Island with the wrecks should also be dredged to a depth of 12 feet, to give a straight cut at least 400 feet wide. The number of cubic yards to be raised is about 94,000.

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After the removal of the cribs in the north channel, and the piling at the head of Elba Island, a cut should be made about 400 feet wide, to connect the 2-fathom curves, having for its southerly edge a rough prolongation of the red curves on the north side of the island. This last cut is not as important as the other, but should be made, to give the current an inclination to the Elba Island side of the channel, as well as to make certain that the channel-way is clear.

The amount to be removed here is about 10,000 cubic yards. Total amount of dredging immediately required, about 200,000 cubic yards, which, at 30 cents per yard for sand, would cost $60,000. To provide for the dredging operations, I would suggest the hiring from the city of Savannah, at a fixed rate per month, calculated to cover the ascertained cost, which is shown to have been about $50,000 per year, of all the appliances for dredging, consisting of a dredge-boat and tender, four flats, employés, &c., the city to defray the whole expense of maintenance and repairs; the work to be done, under the sole direction of the engineer officer in charge, and payments to be made, monthly, deducting for all time lost. In this way advantage will be taken of the arrangements already systematized, and the Government will be at no risk or outlay, payments being only made for work actually done.

The other obstructions to navigation in the river, with reference to which no recommendations are at present made, are as follows:

1st. The "Upper Flats," about two miles below the Elba Island obstructions, and one mile in length, a mud and sand flat, with about 10 feet of water on it at low water covering the whole width of the river.

2d. The "Lower Flats," about a mile below the upper, and half a mile long, of about the same character and depth.

I do not believe that dredging would be of benefit here, and the only remedy will be some system of dikes that, without decreasing too much the flow of water on the flood tide, should restrict the channel to a convenient width, and by this means enhance the depth. This work will be more or less costly, and in view of that fact I am not prepared to submit any plan until I shall have been able to examine more closely the direction of the currents, their strength, and the data of freshets.

The channel north of Oyster Bed, opposite Fort Pulaski, is probably a better channel than the one south, which is now used, as being deeper and straighter. But it remains to be seen whether the tendency is to fill up or to maintain the depth obtained by the city dredge-boat, and until this fact is determined I make no suggestion regarding it. Accidents and long detention have been occasioned by the shoal about midway between Tybee and Fort Pulaski, called the Tybee Knoll, but the light-house department have placed a light-ship there, and I am informed that it is intended to construct a permanent light-beacon on the knoll.

Removing the shoal would be very costly and of doubtful utility. With reference to increasing the flow of water past the city of Savannah, further examination is required.

Back River is a stream of greater capacity than the Savannah River, and leaves it about five miles above the city, uniting again at the lower end of Fig Island. A large volume of water is thus lost to the harbor proper, which, if not allowed to escape, would increase the depth and aid very materially in deepening the "Garden Bank" and the shoal off Fig Island light.

The result indicated can only be effected by partially or entirely closing the upper mouth of Back River, so as to throw into the Savannah all the water it is capable of carrying, and by increasing its capacity by dredging at the narrow portion, but no plan can be considered until both streams have been carefully surveyed to their junction and all the data obtained. I am of opinion that additional benefit will be derived from obstructing Back River, from the fact that I attribute the bend to the northward in the channel at Fig Island to the influence of the flood-tide entering Back River; otherwise the channel would follow the south bank directly to Fort Jackson. It is highly probable that the channel, thus directed, and carrying a largely increased volume of water, would be of greater depth and convenience than ever before.

The question of closing Back River was considered many years ago by engineer officers, and the result of the examination was the construction of the jettee shown on Sheet No. 3. Owing to the opposition of the large rice-planters of South Carolina, and the fact that Savannah was then, compared to its present condition, commercially unimportant, Back River itself could not be obstructed. Now that the interests no longer balance, there would probably be no serious objection on the part of South Carolina which could not be met, and, if necessary, compensation made for actual damage, if any, to individuals on Back River. It would be entirely possible to withdraw a large volume from the river without destroying the accessibility of the plantations for such vessels as are used to transport the crops and supplies. The assignment of a sum of $5,000 has been asked, for the purpose of making the necessary surveys here. I would suggest increasing the sum to $8,000, in order to cover the examinations at other points referred to above. This work can only be prosecuted in the winter and spring, the river and swamps being unhealthy at other seasons; and if a sum sufficient to carry

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on the field-work can be made at once available, it could be applied this winter while operations are being conducted at other places.

In estimating the amount for dredging, I have given only that needed for immediate operations. Since much more should be done, (the channel widened, for example, and the "Garden Banks" entirely removed,) and as this work should be continuous in order to be conducted most economically, I suggest the sum of $100,000, sufficient to keep the dredge in full operation for two years, and at the same time admit, if required, of the use of two boats at once, the tender being able to run for both. In this way the work can be greatly expedited, and at diminished cost.

SUMMARY.

For removing obstructions	$31,800
For removing wreck of Georgia	10,000
For removing dredging	100,000
For survey and examinations	8,000
Total	149,800

Very respectfully, your obedient servant,

WILLIAM LUDLOW,
Captain Engineers, U. S. A.

Major Q. A. GILLMORE,
Corps of Engineers, U. S. A., New York.

Statement showing the value of imports, with duties collected upon articles brought from foreign countries into the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871.

Years.	Value.	Imports.	Remarks.
1860	$1,040,877	.....	The records showing the imports cannot be found.
1861	263,981	.....	
1862	.....	.....	
1863	.....	.....	
1864	.....	.....	
1865	131,274	$76,049	
1866	277,548	159,795	
1867	469,106	229,555	
1868	510,950	276,062	
1869	1,016,005	524,338	
1870	829,483	395,182	
1871	900,065	231,576	To August 31, 1871.

Statement showing the value of exports to foreign countries from the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871.

Years.	Value.	Remarks.
1860	$4,858,372	
1861	14,989,636	
1862	196,110	
1863	275,300	
1864	.....	
1865	2,658,617	
1866	17,846,805	
1867	20,152,641	
1868	24,145,553	
1869	28,490,330	
1870	29,658,606	
1871 (to August 31)	20,026,795	Estimated value for 1871, $34,372,000.

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Statement showing the number and tonnage of vessels engaged in coastwise trade, entered into the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871.

Years.	Number of vessels.	Tons.	Remarks.
1860			
1861			
1862			The records for these years cannot be found.
1863			
1864			
1865	435	168,748	
1866	1,029	424,863	
1867	863	410,143	
1868	715	440,204	
1869	868	517,245	
1870	843	566,777	
1871	465	323,198	To August 31, 1871.

Statement showing the number and tonnage of vessels engaged in coastwise trade, cleared from the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1870.

Years.	Number of vessels.	Tons.	Remarks.
1860			
1861			
1862			The records for these years cannot be found.
1863			
1864			
1865	426	163,944	
1866	956	385,263	
1867	659	359,613	
1868	633	398,014	
1869	695	451,223	
1870	795	509,812	
1871	505	327,171	To August 31, 1871.

Statement showing the number and tonnage of foreign vessels entered from foreign countries into the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871.

Years.	Number of vessels.	Tons.	Remarks.
1860			
1861			
1862			The records for these years cannot be found.
1863			
1864			
1865	23	9,585	
1866	56	32,349	
1867	61	39,723	
1868	90	63,905	
1869	111	80,620	
1870	118	78,334	
1871	93	50,820	To August 31, 1871.

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Statement showing the number and tonnage of foreign vessels cleared for foreign countries from the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871.

Years.	Number of vessels.	Tons.	Remarks.
1860			
1861			
1862	.....	.....	The records for these years cannot be found.
1863			
1864			
1865	13	3,916	
1866	69	38,385	
1867	77	48,797	
1868	111	73,552	
1869	122	90,315	
1870	137	88,718	
1871	131	79,402	To August 31, 1871.

Statement showing the number and tonnage of American vessels entered from foreign countries into the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871.

Years.	Number of vessels.	Tons.	Remarks.
1860			
1861			
1862	.....	.....	The records for these years cannot be found.
1863			
1864			
1865	5	898	
1866	24	8,270	
1867	34	13,519	
1868	49	32,834	
1869	32	16,476	
1870	45	31,182	
1871	52	33,228	To August 31, 1871.

Statement showing the number and tonnage of American vessels cleared for foreign countries from the customs district of Savannah, Georgia, from January 1, 1860, to August 31, 1871.

Years.	Number of vessels.	Tons.	Remarks.
1860			
1861			
1862	.....	.....	The records for these years cannot be found.
1863			
1864			
1865	3	2,334	
1866	52	25,886	
1867	89	45,817	
1868	70	46,682	
1869	80	38,837	
1870	112	70,394	
1871	79	55,505	To August 31, 1871.

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Statement showing the quantities of cotton, lumber, domestics, wool, hides, naval stores, and rice shipped from the port of Savannah, Georgia, to ports within the United States, from January 1, 1865, to August 31, 1871.

Years.	Cotton.	Lumber.	Domestics.	Wool.	Hides and skins.	Naval stores.	Rice.	Remarks.
	Bales.	*M feet.*	*Bales.*	*Bales.*	*Number.*	*Bbls.*	*Casks.*	
1865	98,246	522	7,051	.....	.....	.....	.....	
1866	165,294	14,366	12,028	762	19,364	7,054	1,765	
1867	188,190	9,642	11,166	1,189	55,870	11,815	6,927	
1868	217,418	10,800	9,597	1,135	86,733	9,315	4,489	
1869	205,760	11,615	6,642	568	67,852	4,962	9,284	
1870	240,985	15,840	5,876	965	149,600	864	13,271	
1871	116,960	12,836	4,477	1,502	68,524	.....	8,271	To August 31, 1871.

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SAINT JOHN'S RIVER, FLORIDA.

UNITED STATES ENGINEER OFFICE,
New York, August 31, 1872.

GENERAL: I have the honor to submit the following report of the operations carried on within the past fiscal year upon the bar at the mouth of Saint John's River, Florida, with the object of attaining such an increased depth of water in the bar-channel as will answer the demands of commerce.

Referring to my former reports upon the general question of improving the water-approach to the Saint John's River, so as to provide for the passage of a larger class of ocean and coast vessels than have hitherto been able to enter over the bar, I condense therefrom, as introductory to this report of operations, the following brief *résumé*, touching the general character of the river, and the projects that have been devised and offered from time to time for securing the object in view.

SAINT JOHN'S RIVER AND BAR.

The channel over the bar at the mouth of Saint John's River is situated in latitude 30° 20½′ north, and longitude 81° 31¼′ west from Greenwich. From its mouth to Jacksonville, a distance of twenty-five miles, the general direction of the river is east and west. From Jacksonville to Pilatka, one hundred miles higher up, it lies nearly north and south, being parallel to the main coast, and about twenty miles from it.

"For nearly one hundred miles from its mouth it forms a wide, sluggish sheet of water, more resembling a lagoon than a river, the distance from shore to shore in some places being fully five miles.

"The currents in the river are apparently but slightly influenced by freshets, even during the rainy season, and where most active, near the mouth, are, without doubt, principally due to the tidal wave.

"The waters of the river are never turbid like those of the Mississippi, or like the Altamaha and Santee in certain seasons, and they do not, even when there is a conjunction of strong westerly winds and freshets, exert any considerable agency in the formation of the bar at the mouth of the stream by the deposit of sediment brought down from the interior."

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Six and a half to 7 feet of water can ordinarily be carried over the bar when in its natural condition, at mean low tide, the mean rise and fall being 5.4 feet. After passing the bar a vessel can carry, on the slackwater of flood-tide, 12.7 feet to Jacksonville, where the mean rise and fall is only one foot.

Vessels drawing 10 feet can ascend to Pilatka, and those drawing 8 feet to Lake George, while small steamers ply still higher up.

The area of the water-way at quarantine, three and three-quarters miles from the bar by way of the channel, and just within the point where the stream begins to widen out into the ocean, is 37,625 square feet, with a high-water width of 1,750 feet; while on the bar, measured along the crest line from shore to shore, the water-way is 177,941 square feet, with a width of 16,630 feet.

The channel on the bar is subject to great and sudden changes in depth, direction, and position, due principally to the force and direction of the wind, and secondarily to the influence of freshets upon the current in the river.

Strong westerly winds increase the velocity and duration of the ebb-current, and invariably result in greater depth of water in the bar-channel. Easterly winds produce a contrary effect. They deaden the force of the ebb-current, and the sand thrown up by the ocean waves is deposited upon the bar, instead of being carried out into deep water by the outflowing tide.

"During the prevalence of high northerly or northeasterly winds, a current sets to the southward along the outer edge of the bar, the force of the river-ebb is deadened, and a portion of the sand thrown up by the waves of the ocean inside the sea-buoy, and especially by the ceaseless breakers on the north spit, is deposited and remains in the channel. At the same time the sand set in motion by the waves on the south spit is carried to the southward. The natural results are that the channel-way is moved to the southward with shallowed soundings, the extent of both elements of change depending greatly upon the force and duration of the wind. With strong southeasterly winds, on the contrary, the channel is forced to the northward, accompanied, as before, with a diminished depth of water."

The following are among the most prominent of several projects for attaining greater practicable depth of water on the bar, that have claimed more or less official notice within the last twenty years.

METHOD OF IMPROVEMENT BY STRAIGHTENING THE STREAM.

The freedom of the stream from any large amount of sediment, and practically from all currents except those due to the tidal wave, led to the suggestion some years ago of a means of improvement by straightening some of the short curves in the channel below Jacksonville, between Point Suarrez and Mill Cove Point.

It was assumed, doubtless correctly, that a less crooked and therefore shorter channel would result in augmenting both the volume and duration of the inflowing tidal wave, as well as the period of high-water navigation on the shoals below Jacksonville, and the scouring effects of the ebb-current upon the bar. But whether this scouring effect would take place principally in the bar-channel, so as to produce greater useful depth of water at that point, or would be dissipated over the entire bar, which is over three miles in length from shore to shore, is a question surrounded with such uncertainty that I have always regarded the trial of this method of improvement as inexpedient,

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until other plans, promising more certain results, should have been attempted without adequate success.

Since my report of January 29, 1869, was submitted, (see Report of the Chief of Engineers, 1869, page 267,) in which this judgment is expressed, a survey and examination has been made, under my direction, of the shoals in the vicinity of the short curves referred to, without eliciting any facts, or furnishing any data, justifying a change or modification of my views.

IMPROVEMENT BY MEANS OF PIERS AT THE MOUTH.

A plan of improvement, which is very naturally suggested by the character and length from shore to shore of the Saint John's Bar, is one by piers, which shall confine within narrow limits the waters which now flow out through a shallow water-way, over three miles wide, measured along the crest of the bar.

It is possible that a single pier or jettee, constructed along the north side of the channel, and reaching from the shore to the outer edge of the bar, would answer the purpose. It is probable, however, that two such jettees, one on each side of the channel, would be necessary, otherwise the water-way might widen out on the unprotected side, even to its present dimensions. A project of this character, by a single pier, was submitted by a commission some eighteen years ago, but never received official sanction.

Its estimated cost, in 1854, was $196,000, which would have to be nearly, if not quite, doubled to meet the present price of materials and labor. As no considerable benefit could be derived from the adoption of this method of improvement much short of its entire completion, I have never favored or recommended it. (See Report of the Chief of Engineers for 1869, page 268.)

IMPROVEMENT BY CLOSING FORT GEORGE INLET.

The mouth of Fort George Inlet is about two miles northwest of the mouth of Saint John's River, measured in a straight line between the two bar-channels. The inlet, though very narrow, empties into the ocean over a shoal nearly two miles long from shore to shore at high tide. Inside, for about two miles from the bar, the direction of the channel is north and south, and at a point one mile higher up it connects with the inside passage from Nassau Sound to Saint John's River through Sawpit Creek and Sister's Creek.

A theory has been advocated—

That there is on each tide an interchange of waters, in large volumes, between Saint John's River and Fort George Inlet; that the waters thus exchanged flow through swash channels and otherwise over the north shoal, and not around by the main channel across the bar, and that while this flow is taking place from the river to the inlet—that is, during the ebb-tide—it increases the outward current over the shoal, thereby still further diminishing the volume of water which would otherwise pass out by the main channel.

As already stated, the flood-current in the inlet begins with the flood-tide, or thereabout, and from one and a half to three hours before the ebb-current ceases in the river at the bar, and perhaps a short time before it ceases on the north shoal, and it may be, and probably is, true that during this interval a portion of the river-waters flow out over the north shoal near the shore, and thence into the inlet; but I cannot concede the conclusion assumed, that if the mouth of the inlet be closed these waters would not continue to pass out over the north shoal and thence into the ocean, but would naturally and of necessity flow over the bar-channel, thereby adding to the velocity and scouring effect of the ebb-current.

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IMPROVEMENT BY AN INSIDE SHIP-CHANNEL FROM FERNANDINA, AVOIDING THE BAR.

I have recently, under date May 10, 1872, submitted to the Chief of Engineers a report upon a project for constructing a ship-channel from Fernandina, Florida, to Saint John's River, in response to a memorial to Congress from the legislature of Florida, approved May 31, 1871, asking an appropriation of $250,000 for that object. The construction of such a channel will involve the expense of dredging out, to a suitable width and depth, certain shallow portions of the several watercourses which constitute the present inside passage, and making several straight cuts through the marsh to avoid sharp curves in the natural channel.

The entire length of the passage over the route which, from the most trustworthy information in my possession, appears to offer the greatest advantages, is twenty-nine and a half miles, and the estimated cost of its construction to admit the passage of vessels drawing 15 feet water, on the slackwater of high tide, is $750,000. This includes a little over $10,000 to be expended in dredging, to 15-feet soundings, the Saint John's River Shoals near Dame's Point and San Carlos Creek.

IMPROVEMENT BY AN INSIDE SHIP-CHANNEL FROM NASSAU SOUND.

If the northern terminus of the inside ship-channel be located in Nassau Sound, the total length of the improvement would be only nine and three-quarters miles, and the estimated cost of its construction for vessels of 15 feet draught is a little over $600,000. This includes the necessary dredging in Saint John's River, as before, and in addition the first cost of deepening the channel on the Nassau Bar, from its present high-water depth of 14½ feet to the required depth of 16 feet.

The proper depth for this inside channel would be 14 feet at mean high water, corresponding to the natural depth on the Nassau Bar, increased 6 to 9 inches, as it probably would be from frequent use, and allowing for the usual ocean-swell.

I have no suitable data in my possession, nor do I know of any in existence, upon which a satisfactory estimate of the cost of such a channel can be based.

As I deem it desirable that such an estimate should be made, in order that some plan of permanent improvement of the water-approach to the Saint John's River, that shall satisfy the demands of commerce, may, if practicable, be devised without unnecessary delay, I repeat the opinion expressed at the close of my report of May 10, 1872, "that the definite determination of the question whether a ship-channel from Nassau Sound to Saint John's River, corresponding to the natural high-water depth on the Nassau Bar, can be constructed at a reasonable cost, should receive the earliest possible attention."

TEMPORARY IMPROVEMENT NOW IN PROGRESS BY DREDGING OF SAINT JOHN'S BAR.

Under the act approved July 11, 1870, appropriating $15,000 toward the improvement of the mouth of Saint John's River, a contract was entered into October 19, 1870, for enlarging and maintaining the bar-channel by dredging, raking, or otherwise, at the option of the contractor, to a width of 80 feet, and a depth of 10 feet at low water, for the sum of $1,200 per month, with a provision for a proportional increase in

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the amount to be paid for each and every additional width of 5 feet, within such limits as the superintending engineer should approve.

Under that contract an additional depth of 1½ to 2 feet was several times attained, but the appliances employed by the contractor being insufficient, and his means inadequate to a vigorous prosecution of the work, the contract was annulled under authority given May 22, 1871, and the execution of the work was assumed by the United States.

No payment was ever made under this contract, the stipulated width and depth of channel never having been attained.

The plan which I then recommended, and which has since been carried into successful execution, is briefly as follows, viz, to procure by charter a suitable steamer, and furnish her with one nine-inch centrifugal-drainage pump, two branches of 6-inch suction-hose, and timber-bins on deck for holding the sand; the pump-engine to be connected with the steamer's boiler. The sand to be discharged at points selected for the purpose, either inside or outside the bar, by flooding the bins with clear water.

This method of dredging was adopted because it appeared to give greater promise of beneficial results at an early day, with less original outlay for apparatus than any other. It was not deemed practicable, on account of the heavy swell almost constantly prevailing on the bar, to discharge the sand from the pump or any other dredging-machine into lighters alongside the dredging-boat, nor was it deemed expedient to incur the expense of a boat constructed specially for the purpose.

DESCRIPTION OF DREDGING-STEAMER AND APPARATUS.

The steamer, originally built for carrying passengers and light freight, is 132 feet long on the keel, 24½ feet broad on the beam, and when ballasted on an even keel draws about 5½ feet of water. She was modeled with a view to speed, and carries only 100 tons on a draught of 7 feet, is strongly built, with side wheels and short guards, has one low-pressure engine of 120 horse-power, and ample boiler capacity. Although the most suitable boat for the purpose that could be chartered at the time, she is not exactly adapted to the work required of her, on account of her comparatively deep draught and small carrying capacity, which renders it impossible to prosecute work continuously during the period of low water. A boat with more beam, and a fuller model fore and aft under the water-line, would have been better.

The pump, a No. 9 centrifugal-drainage pump, of the Andrews patent, is located on the main deck, aft, about 35 feet from the stern-post. Its main suction and discharge openings are each 9 inches in diameter. To the suction-opening there are connected by a two-way branch-pipe, two 6-inch suction-pipes, instead of one 9-inch, as usual, the object being, in dredging on the Saint John's Bar, not only to work on both sides of the boat simultaneously, but to render the necessary handling of the pipes as easy and prompt as possible. There is, on the other hand, considerable disadvantage in operating with two suction-pipes instead of one, on account of the greater amount of friction for an equivalent suction capacity, for while a 9-inch pipe has an area of 81 circular inches, two 6-inch pipes have an aggregate area of only 72 circular inches. The frictional surface is therefore increased as 27 to 36, making the disadvantage from this cause as 2 to 3. The discharge of materials is made through a 9-inch pipe branching in a two-way pipe into two 6-inch discharge-pipes.

It was necessary also to encounter another disadvantage by using

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several bends, of which there were two in each of the suction-pipes, one in the main discharge-pipe, one in one of the 6-inch branch discharge-pipes, and two in the other; those in the suction being each one-eighth of a circle, and those in the discharge one-fourth of a circle each.

These bends reduce the delivery at the rate of 10 per cent. for each turn of 90°, and about 6 per cent. for each turn of 45°, these reductions being calculated for each case upon the quantity passing the preceding bend. Thus the first one-eighth bend in the suction reduces the quantity to 94 per cent., the second to 88 per cent., and the one-fourth bend in the main discharge to 79 per cent., one-half of which is reduced by one bend in one of the branch discharge-pipes to 36 per cent., and the other half by two bends in its discharge-pipe to 31 per cent., leaving for the net delivery 67 per cent. of the theoretical quantity pumped.

The disadvantages, therefore, under which the apparatus labored may be briefly summarized as follows:

1. The loss by friction, due to the use of two 6-inch instead of one 9-inch suction-pipe, is increased 50 per cent.

2. The loss by friction due to the use of suction-pipes three times as long as the height to which the material is to be raised.

3. The loss of 33 per cent. in the theoretical quantity pumped up by bends in the suction and discharge pipes.

As the pump will not charge itself, the charge is supplied by a small donkey-pump, through a hole made in the top for that purpose. The charge is retained while turning the boat on the inside of the bar, and during the night, and at other intervals when work is temporarily suspended, by closing the side-valve in each of the suction-pipes, where it passes over the side of the vessel.

The engine used to drive the pump consists of two cylinders connected upon one crank, at right angles to each other, and 10 inches in diameter by 10 inches stroke each. Steam is conveyed from the steamer's boiler to the pump-engine through a 3-inch iron pipe, the usual pressure carried upon the boiler being about 25 pounds to the square inch. This pressure develops about 26 useful horse-power, after deducting 25 per cent. for friction of engine and difference of pressure in the cylinder and boiler, and gives a speed of about 180 revolutions per minute to the engine-shaft. On this shaft is a pulley 42 inches in diameter, carrying a rubberbelt 12 inches wide, communicating the power to the pump-shaft through a pulley 24 inches in diameter, thus giving the pump-disk and wings about 315 revolutions per minute. This speed in the No. 9 pump is equal to the work of raising 3,000 gallons of clear water per minute, 30 feet high, through a 9-inch straight vertical pipe.

The actual height raised above the surface of the water on the Saint John's Bar varies, with the amount of sand taken on board, from 10 to 11 feet, but as the pipes are 50 feet long, with bends, and are in two branches instead of one, and as a mixture of sand and water is heavier and more impeded by friction than clear water, the loss by friction, from all these causes combined, reduces the useful work of the pump considerably below the average attainable under more favorable conditions. For these reasons, although 200 revolutions of the pump-disk per minute will easily raise 3,000 gallons of clear water 12 feet high through a vertical 9-inch pipe, 300 revolutions are required to raise 2,500 gallons of sand and water 11 feet high through two inclined suction-pipes, having two turns each, discharged through a pipe having one turn.

To prevent the ends of the suction-pipes being lifted off the bottom by the pitching of the boat, a portion of each pipe is made flexible, being composed of 6-inch rubber hose stretched over a spiral spring. In addi-

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tion, the ends are loaded with an iron frame or drag, each weighing about 200 pounds, which is intended to move along flat upon the bottom during the operation of dredging. To the under surface of this frame, directly below the mouth of the pipe, a number of teeth or knives are attached, to stir up the sand and aid its entrance into the pipe.

A chain, attached to each drag, and leading to the deck of the steamer on either side, takes the strain from the pipe when the drag is down and the steamer in motion. Another chain runs along the pipe, and is attached to all the flanges.

Tackles are arranged for lifting the pipes from the bottom when not dredging, or when pumping clear water, to discharge the sand from the bins.

For receiving the sand, bins are located along the main deck, fore and aft, on each side of the steamer's engine, each being provided with a sliding gate over the steamer's side, which can be opened and closed at pleasure. The bins are filled from two troughs, one from each branch of the discharge-pipe, provided at suitable intervals with valves or gates, so that the load can be distributed to the bins wherever desired.

The total expense of fitting up the steamer with pump, pump-engine, bins, pipes, and all the requisite appliances for commencing work, is detailed below, as follows:

One double-oscillating engine, with outside stand, 10 inches diameter of cylinder, and 10-inch stroke	$1,250 00
One No. 9 centrifugal-drainage pump, with stand	670 00
1 42-inch pulley, 1 24-inch pulley, and 34 feet of rubber belting	135 00
40 feet of rubber suction-pipe, (6-inch)	500 00
87 feet of galvanized-iron suction-pipe, (6-inch)	425 00
2 drags	100 00
2 discharge-pipes	40 00
93 feet of steam-pipe	120 00
4 3-wheel valves	80 00
Turn-bends, branch-pipe, joints, bolts, nuts, washers, flanges, elbows, angle-pieces, &c., for fitting and connecting machinery	530 00
Labor on same	300 00
Total for pump and engine	4,150 00
Derrick and fixtures	300 00
Winch	35 00
Davits	60 00
Rope and chain rigging, &c., engineer's tools and supplies	305 00
Sand-bins, complete	1,450 00
Total	6,300 00

The steamer was chartered for $2,500 per month, which covered the cost of the fuel and the wages of the crew, consisting of master, mate, engineer, pilot, fireman, cook, and deck-hands. The United States supplied a superintendent, an engineer for the pump, and two laborers, at an aggregate monthly expense of $340. The total monthly expense for dredging, inclusive of charter, wages, current repairs, and interest on the sum expended in fitting up the vessel, was a trifle under $3,000, or $100 per day, including Sundays.

The proportion of sand that can be pumped depends greatly upon its specific gravity and degree of fineness. The calcareous and argillaceous sands flow more freely than the silicious, and fine sand is less liable to choke the pipe than those that are coarse. When working at high speed, 50 to 55 per cent. of sand can easily be raised through a straight, vertical pipe, giving for every ten cubic yards of material discharged five to five and a half cubic yards of compact sand.

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With the appliances used upon the Saint John's Bar, and in consequence of the swell, which frequently lifted the ends of the suction-pipes from the bottom, the proportion of sand seldom exceeded 45 per cent., generally ranging from 30 to 35 per cent., when working under the most favorable conditions. In pumping 2,500 gallons, or 12.60 cubic yards of sand and water, per minute, we would, therefore, get from 3.7 to 4.3 cubic yards of sand. During the early stages of the work, before the teeth under the drags had been properly arranged to aid the flow of sand into the pipes, the yield was considerably below this average, not often greatly exceeding and frequently falling below 2 cubic yards of sand per minute, during the time actually occupied in pumping. At a later period much better results were obtained.

The manner of conducting the dredging may be briefly described as follows:

The steamer, with the suction-pipes up, first crosses the bar to the outside, then turns around and steams slowly in over the bar, with just sufficient speed to maintain steerage-way, lowering the pipes and starting the pump, as soon as the outer edge of the bar is reached. Arriving on the inside the pump is stopped, the pipes raised, and the steamer turned around again. She then crosses slowly to the outside, pumping as before, and the quantity of sand discharged into the bins, during these two passages over the bar, is a load, whether great or small. While the steamer is turning around on the outside, preparatory to taking in another load, the side-gates to the bins are opened, the suction-pipes are raised from the bottom, and the pump is run at full speed on clear water. By this means, assisted to some extent, where necessary, by men in the bins with hoes, the sand is all discharged into deep water by the time the steamer again reaches the outer edge of the bar, when the dredging is resumed.

The time required to turn the steamer twice is 12 to 13 minutes, of which only 6 to 6½ minutes, or the time occupied in making the turn on the inside, is lost, as neither the work of dredging the sand nor discharging it from the bins is in progress during that interval.

I append hereunto a statement in tabular form, compiled from the journal of dredging operations kept by the superintendent in charge of the work, from November 1, 1871, to June 1, 1872, closing with a recapitulation, which shows for each month the number of working days, the total number of hours worked, the quantity of sand removed in cubic yards, the cost of removal per cubic yard, and the average cost during the whole period of seven months.

The dredging-steamer was transferred to Charleston on the 1st of June, 1872, but returned to and resumed work upon the Saint John's Bar before the close of the month. The journal of operations does not embrace the work done in June.

GENERAL OBSERVATIONS.

1. The least cost during any one month, for dredging and dumping the sand, was in May, 1872, when it amounted to 26 cents per cubic yard.

2. The greatest cost for any one month was during December, 1871, when it reached $1.22 per cubic yard.

3. The least cost during any one week for dredging and dumping was 19 cents per cubic yard.

4. The least cost for any one day was on May 14, 1872, when 770 cubic yards were removed in 10⅙ hours, at a cost of only 13 cents per cubic

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yard, the time actually occupied in raising sand being only 5 hours 46 minutes.

5. The average cost for the entire period of seven months was 52⅞ cents per cubic yard.

6. The amount, exclusive of outfit, actually expended by the United States for dredging and current repairs, during the seven months, in removing 36,969 cubic yards of sand, was $19,450, and the number of hours occupied at the bar in doing the work was 622¾. The number of hours lost, including Sundays paid for, and estimating the days at 10 hours each, was 1,347¼, equal to 68½ per cent. of the whole time. This lost time, with the exception of sixteen days chargeable to the boat and deducted from the charter, was nearly all occasioned by bad weather and low water on the bar. There were a few stoppages of short duration to repair the pumping-apparatus.

Assuming that no time had been lost from bad weather or insufficient depth of water, or that the operations had been carried on in still water, with a boat that could work during low tide, the dredging would have cost less than 17 cents per cubic yard. This price covers the entire period of seven months, during a considerable portion of which, before the suction had been properly adjusted, the proportion of sand raised was considerably below the average and greatly below the maximum results.

7. It may be remarked, in this connection, that there would be some difficulty in managing a boat of very light draught in such a heavy sea and strong current as usually prevails upon most of the ocean-bars on the Atlantic coast, and in dredging upon very shallow ocean-bars, even a boat built expressly for and well adapted to the work, might necessarily draw too much water to work continuously during low tide in the earlier stages of the operation.

8. During the first five months of the operations, (November 1 to April 1,) the average duration of a round trip, in taking in and discharging a load, was $29\frac{7}{10}$ minutes, of which only $17\frac{2}{10}$ were occupied in dredging.

During the last month, when the channel was longer, the round trip occupied 30⅙ minutes, 18 minutes being occupied in dredging.

The average duration of a round trip during the seven months was 30⅜ minutes, and the average time per trip occupied in dredging was $17\frac{6}{10}$ minutes. The pump was, therefore, actually employed in raising sand only 58 per cent. of the whole time spent at work upon the bar.

9. In dredging in still water this large percentage of lost time would be saved, as the dredging could go on uninterruptedly, into scows or lighters ranged on either side the dredging-boat.

There are localities where the dumping-scows could, doubtless, be dispensed with, and the sand conveyed in spouts, or forced through pipes, directly to the dumping-ground. Of this character, as a class, are narrow streams having their channels near the shore, and many of the harbors on our northern lakes, where the bars occur between parallel piers. In the former case the sand could be discharged on or near the shore, and in the latter over the piers on either side.

With the centrifugal-drainage pump sand can be easily discharged at a height of 30 feet above the level of the water, and when the distance to which it has to be conveyed is so great that open troughs from the discharge-pipe to the dumping-ground cannot have sufficient inclination to secure a free flow of the sand and water, it would be necessary to make the discharge through pipes, increasing the power in proportion

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to the length of pipe, so as to insure a velocity that will prevent choking. The pump should be placed as low as possible.

The cost of dredging under these conditions would probably not exceed 10 to 11 cents per cubic yard, inclusive of running expenses, wear and tear of machinery, and all stoppages and other contingencies.

Indeed, assuming the pump on the Saint John's Bar to have worked continuously in raising sand ten hours per day, except Sundays, during the month of May, 1872, with the same average results per hour actually attained while pumping, thus charging the six working days of each week with the expense of seven, the cost for raising the sand would have been only $8\frac{6}{10}$ cents per cubic yard, and if it could also have been continuously discharged to the dumping-ground through open troughs or pipes, no additional expense would have been incurred.

There were, moreover, constant losses incurred on the bar in consequence of the ends of the suction-pipe being frequently lifted off the bottom by the pitching of the boat, which would be avoided in still water. Ten to eleven cents per cubic yard may therefore be adopted as a liberal estimate for dredging and dumping sand when the work can go on continuously without scows.

The total quantity of sand removed from the Saint John's Bar during the fiscal year ending June 30, 1872, was 40,764 cubic yards, at an average cost for current expenses of $50\frac{9}{10}$ cents per cubic yard.

The channel established has a direction due east and west, and is $9\frac{7}{10}$ feet deep, and considerably over 150 feet wide at mean low water. Its length is about 800 yards at low water, on the line of greatest depth.

There being a mean rise and fall of $5\frac{4}{10}$ feet upon this bar, the mean high-water depth established is over 15 feet, so that vessels drawing $13\frac{5}{10}$ feet to 14 feet can cross the bar, except in very rough weather. In a very heavy sea, a vessel drawing 13 feet might touch.

Upon the shoals near Dame's Point and San Carlos Creek, below Jacksonville, there is a mean low-water depth of 10 feet, with a mean rise and fall of $2\frac{7}{10}$ feet. There being no swell there, vessels drawing $12\frac{7}{10}$ feet can cross. There would, therefore, be no advantage in establishing a greater depth than we now have upon the bar, unless the channels over the shoals were correspondingly deepened, inasmuch as all vessels entering the river are bound to some point above these shoals.

It is recommended that channels $9\frac{6}{10}$ feet deep and 150 feet wide at low water, on the bar, and $11\frac{3}{10}$ feet deep and 150 feet wide at low water over the shoals, be maintained for the accommodation of vessels of a maximum draught of 14 feet. This will necessitate the removal of 8,000 cubic yards of materials from the channels over the shoals, at an estimated cost of $3,500. Some parts of the new channel, in the vicinity of San Carlos Creek, will be liable to fill up, but no estimate of the extent to which the dredging will have to be repeated can be made in advance.

The natural bar-channel has never been permanent in either depth, position, or direction, and it is not expected that the channel now established can be maintained without occasional, and, perhaps, frequent dredging. No estimate of the quantity of sand to be removed to secure any specified depth, where the conditions are so fluctuating and so completely beyond control, can be formed.

The amount of annual expenditure necessary to maintain a given depth will depend greatly on the number, violence, and direction of the prevailing storms. A sum which would be barely sufficient to maintain a 9-foot channel during one season, might, during another, establish a

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greater depth, and leave a balance to expend in gaining a corresponding increase on the shoals.

I invite attention to a chart of these shoals from a survey made in January, 1872, forwarded to the Chief of Engineers with my letter of March 25, 1872.

I recommend that $20,000 be appropriated for the fiscal year ending June 30, 1874, for the improvement of Saint John's River, Florida, to be expended in dredging upon the bar at the mouth of the river, and upon the shoals in the vicinity of Dame's Point and San Carlos Creek.

An outline drawing of the dredging-steamer and pumping-apparatus hereinabove described, with the suction-pipes lowered upon the bottom, in the position occupied by them when pumping sand, is herewith transmitted.

Certain of the more important details, not plainly exhibited in the general drawing, are shown on an enlarged scale.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major of Engineers, Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

IMPROVEMENT OF THE BAR AT THE MOUTH OF THE SAINT JOHN'S RIVER, FLORIDA.

Financial statement for the fiscal year ending June 30, 1872.

DR.

To amount available July 1, 1871	$29,665 93
To amount appropriated by act approved June 10, 1872	10,000 00
To amount due superintending engineer, as per account-current second quarter 1872	137 58
	39,803 51

CR.

By amount expended during fiscal year ending June 30, 1872	$29,803 51
By amount in United States Treasury to credit of appropriation for the work	10,000 00
	39,803 51
Amount available July 1, 1872	$9,862 42

P 5.

SAINT JOHN'S RIVER, FLORIDA.

UNITED STATES ENGINEER OFFICE,
New York, March 25, 1872.

GENERAL: I have the honor to report that I have to-day forwarded to you, by express, a chart of that portion of the Saint John's River, Florida, surveyed by my direction, under the act of Congress, approved March 3, 1871, requiring an examination or survey, or both, at the mouth of that river, "from the outer bar to Jacksonville, Florida."

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The only points where instrumental surveys were deemed necessary are the shoals in the vicinity of Dame's Point, as shown on the chart. In this portion of the river the channel has shoaled to some extent since the last survey was made, by the Coast-Survey establishment, in 1856.

In my judgment, any contemplated improvement of this river should have for its object simply to provide an uninterrupted channel from the ocean to Jacksonville, corresponding to the greatest depth of water that can be secured, at reasonable cost, on the bar at the mouth of the stream.

This will require some dredging on the shoals above named. The mean rise and fall of tide is 5.4 feet at the outer bar, and 2.7 feet at Dame's Point, a difference of 2.7 feet, of which about 1 foot is practically eliminated by the prevailing swell on the bar.

In ordinary weather, when no storm prevails, a vessel drawing 11 feet of water would require 12 feet soundings to enable her to cross the bar without striking. In a heavy swell she would strike in 12½ feet, or even 13 feet, unless she was of full model under water, fore and aft. At Dame's Point, however, the question is one of very nice and easy adjustment. There is no swell there; the bottom is softer than that upon the bar, and an inch of water under the keel is quite sufficient, unless the wind renders it impossible to keep precisely in the channel.

On account of the great swell which always prevails upon the Saint John's Bar in easterly, northeasterly, and southeasterly storms, no vessels, except those of light draught, would cross it for refuge in heavy weather. Nassau Inlet, seven miles farther north, is a better harbor, and Fernandina, nineteen miles distant, is an excellent one. I think, therefore, that the difference in the channel-depths to be established upon the Saint John's Bar and at the Dame's Point Shoal, respectively, should be fixed with special reference to the passage of vessels in fair or moderate weather, so as to afford just sufficient water over the shoals for the largest-draught vessels that can safely cross the bar on slack-water of floodtide. This will require, at low water, about 1.7 of a foot more depth upon the shoals than is necessary upon the bar. If the latter be fixed at 9.6 feet, and the former at 11.3 feet, a vessel drawing 14 feet will cross the bar on slackwater flood in 15 feet sounding, and will just graze the bottom of the shoals.

The bar-soundings should govern in this matter, on account of the greater expense of dredging in that exposed position. The heavy swell there occasions repeated and prolonged interruptions of the work.

I am not yet able to state, with minute exactness, the depth of water that can be maintained there at reasonable cost, and am, therefore, unprepared, for want of data, to submit a project for the improvement of the river above the bar. The money I am now expending is applicable to the bar exclusively. Any future appropriations should be made for the improvement of Saint John's River, below Jacksonville, so that the dredging-boat can work upon the shoals near Dame's Point, when the weather prevents operations upon the bar.

I reserve for a future communication, which I hope to be able to make some time during the coming month, my recommendations with reference to the improvement of the Saint John's River in the vicinity of Dame's Point.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major of Engineers, Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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UNITED STATES ENGINEER OFFICE,
New York, May 10, 1872.

GENERAL: I have the honor to state that, under date February 14, 1872, there was transmitted to me by the Chief of Engineers, for report thereon, a "memorial of the legislature of Florida, approved May 31, 1870, relative to the improvement of the harbor of Saint John's River and of Fernandina, Florida," and asking an appropriation for the same of $250,000, the character and object of the contemplated improvement being to provide a ship-channel "by dredging out the inside passage between the Saint Mary's and the Saint John's Rivers to a depth of 13 feet," so that vessels going up the Saint John's River would enter at the harbor of Fernandina.

My views upon this subject, based upon such data and information as I have been able to collect, some of which are incomplete and, therefore, not entirely satisfactory, are briefly as follows:

The language employed in the memorial is somewhat vague and contradictory, inasmuch as the natural and most direct route from the harbor of Fernandina to the waters of the Saint John's River does not enter or touch the Saint Mary's River at all. Saint Mary's River is a tributary of Cumberland Sound, (or Fernandina Harbor,) entering it from the west, and Amelia River is another tributary entering the sound from the south, and forming the western boundary of Amelia Island. The town of Fernandina is located upon Amelia Island, on the east bank of Amelia River, at a distance of two and one-half statute miles from its mouth on Cumberland Sound.

The memorial suggests dredging out the inside passage to a depth of 13 feet, but does not state whether this depth refers to high water or low water.

The distance in a straight line from Fernandina to the nearest point on Saint John's River is twenty-five statute miles, in a direction a little west of south, and there now exists a continuous tide-water channel, occupying the same general direction connecting the waters of Cumberland Sound with those of the Saint John's River, which, although very crooked and narrow in places, is navigable by steamers of light draught. The difficulty encountered in this navigation is not exclusively a want of sufficient depth of water. There is constant danger of grounding at the sharp curves in the stream, and a resort to special means is frequently necessary to pass them, even by small steamers.

Starting from Fernandina, this inside passage is made through Amelia River for about three miles, thence through Kingsley's Cut, a distance of seven and one-fourth miles, thence through South Amelia River three miles, thence through a portion of Nassau Sound three miles, and thence through Saw-pit Creek and Sister's Creek thirteen and one-fourth miles to the Saint John's River, the whole length of the passage being twenty-nine and one-half miles.

The Coast Survey has supplied me with a chart amply sufficient for the purposes of a general report of all this passage, except about eleven miles measured by the channel next the Saint John's River and lying between that river and Nassau Sound.

A survey, apparently not very thorough in character, of the southern portion of this route from Nassau Sound to Saint John's River, was made last year by Mr. C. F. Smith, assistant engineer of the Jacksonville, Pensacola, and Mobile Railroad in the interest of that company and the Atlantic and Saint John's Dredging and Towin Company, with a view to the construction of an inside ship-channel, by which vessels could enter the Saint John's River by way of Nassau Inlet.

I have deemed it admissible to use the meager information given by Mr. Smith, and make it suffice for this general report, rather than wait for a satisfactory survey of this portion of the passage, although his chart does not give any soundings, and is not drawn to any recognizable scale.

The route selected and recommended by Mr. Smith enters by the Nassau Bar Channel, traverses Nassau Inlet and Sound for a distance of nearly four miles to the mouth of Saw-pit Creek, where it is obstructed by a small bar, then enters Saw-pit Creek Channel, having a depth of 12 feet and over, and following it in a westerly direction slightly diverging from the river for about half a mile, where a turn is made to the south, still continuing in the creek a further distance of three-eighths of a mile. From this point a line of half a mile in length, running a little west of south, and passing on the marsh, meets the creek, (after its having made a large bend,) where its channel is again resumed for a distance of one-quarter of a mile. From here the creek pursues a course so much out of the general direction of the route that a line on the marsh of one mile in length in a southeasterly direction is adopted, crossing the creek once and reaching it again near the southern terminus of the place known as Gunnison's Cut, from which its channel is made the line for a distance of half a mile, when the marsh is again resumed for one-eighth of a mile, bringing the line to the creek, which, continuing past Fort George Inlet, and entering the Sister's Creek, is adopted for a distance of one and three-quarters miles. Thence on the marsh nearly southwest, the line extends one-quarter of a mile, meeting the creek, which is followed half a mile. Leaving the Sister's Creek at this point, the line pursuing a southwesterly direction on the marsh for a distance of one and three-eighths miles, reaches the Hannah Mills Creek, which it follows three-quarters of a mile to its junction with the Saint John's River.

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This gives for independent canal a distance of three and one-fourth miles, and for creek navigation, four and five-eighths miles, or a total of river, creek, and canal navigation from the Nassau Bar to the Saint John's River, of about twelve miles. From the same points, by way of the Saint John's Bar, the distance is about fourteen miles.

Upon a small chart accompanying Mr. Smith's report, it is stated that the average high-water depths in the creeks through which the channel is to run is 12 feet; that the bottom is marsh-mud to a depth of 4 feet, and that the material below this is sand. It is further stated that the bar at the mouth of Nassau Inlet has 16 feet of water upon it "at full tide," which exceeds, by nearly 2 feet, the depth reported by the Coast Survey from an examination made in 1870, and I understand his project to be, although it is not clearly set forth in his report, to dredge out the bar-channel to a width of 300 feet, and a high-water depth of 16 feet, and to make the inside passage from Nassau Sound to the Saint John's River of a corresponding depth, so that vessels can pass through with the greatest draught of water that can be carried over the bar in ordinary weather. Allowing 1 foot for the swell on the bar, there would be required 15 feet at high water, or about $9\frac{1}{10}$ feet at low water, through the inner passage.

I have assumed, therefore, that the estimated cost of constructing this inner passage from Nassau Sound to Saint John's River, was based upon a high-water depth of 15 feet to be attained in the creeks and straight cuts, upon the presumption that a corresponding depth of 16 feet could be carried over the Nassau Bar at high water, in ordinary weather; and with this understanding, I have adopted as correct the estimated quantities of dredging upon that portion of the passage south of the sound.

North of Nassau Sound the natural water-course is followed throughout, with the exception of one straight cut about one-fourth of a mile long, to avoid a sharp elbow in Kingsley's Cut.

In the following estimate, the "price per cubic yard" is based upon the actual cost of similar work performed in Savannah River, by the authorities of the city of Savannah, where order, system, and economy appear to have prevailed.

Estimated cost of constructing an inside ship-channel, 15 feet deep at high water, from Fernandina to Saint John's River, Florida, inclusive of dredging in Saint John's River.

To be removed.	Materials, and where located.	Price per cubic yard.	Amount.	
Cub. yds.				
42, 400	Loam and sand in Kingsleys's cut for channel, 200 feet wide	$0 32	$135, 680	
121, 000	Loam and sand in canal across elbow in Kingsley's cut, for channel 125 feet wide	32	38, 720	
	Total from Fernandina to Nassau Sound			$174, 400
1, 138, 000	Loam and sand in canals, 125 feet wide, south of Nassau Sound	32	364, 160	
414, 000	Sand in creeks south of Nassau Sound channel, whole width of creek, generally	34	140, 760	
	Total from Nassau Sound to Saint John's River			504, 920
14, 200	Loam and sand in Saint John's River, near Dame's Point, for channel 200 feet wide	32		4, 544
17, 800	Loam and sand near San Carlos Creek	32		5, 696
	Total from Fernandina to Jacksonville, Florida			689, 560
	Add 10 per cent. for contingent expenses			68, 956
	Total			758, 516

I have incidentally mentioned the project of constructing an inside ship-channel from Nassau Sound to Saint John's River, having its entrance from the ocean over the Nassau Bar, in behalf of which Mr. Smith made the survey already referred to. If the reported depth of 16 feet "at full tide" were correct, and represented the normal condition of the channel upon the Nassau Bar, this route would be preferable on account of its permanency—after the requisite creek-dredging and canal-cuts had been made—to that by the Saint John's Bar, over which it cannot be expected that more than 15 feet high-water depth can be maintained by more or less constant dredging, at an expense of $12,000 to $15,000 per annum.

But as the reports from the Coast Survey show that the Nassau Bar has only $14\frac{1}{2}$ feet of water upon it at high tide, while the Saint John's Bar in its natural condition has from 12 to $12\frac{1}{2}$ feet, the difference is not, in my judgment, sufficiently great to justify any large expenditure in the construction of a ship-channel with its entrance at Nassau Inlet. It is true that the Nassau Bar channel could be deepened to 16 feet high

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water, at perhaps less expense than would be required to attain 14½ to 15 feet on the Saint John's Bar, and with possibly a better promise of permanency, on account of the more nearly uniform section, and more rapid current of the stream; but the same objections practically apply to both, that they would be constantly liable to be filled up by storms to their normal condition, and this might occur at a time when a large amount of shipping would be detained inside to await the tedious and somewhat uncertain operation of dredging, in an exposed position, subject to frequent and prolonged interruptions from heavy weather.

I am not prepared, therefore, from the judgment formed upon the incomplete *data* within my reach, to recommend an appropriation for the construction of a ship-channel from Nassau Sound to the Saint John's River, corresponding to a high-water depth of 16 feet upon the Nassau Bar, for the reasons, briefly—

1. That its first cost would be very great as compared with the general benefits to be derived from it.

2. That it would be necessary to dredge out and maintain a channel over the Nassau Bar, about 2 feet in excess of the natural depth, liable at any time to be filled up by storms.

The approximate cost of constructing such a channel is given below, assuming as correct Mr. Smith's estimates of the quantities of materials to be removed in deepening the creeks and constructing the canals. The quantity of material to be removed from the bar is estimated from a manuscript chart furnished to me by the Coast Survey, and the estimated cost of its removal is based upon the actual cost of precisely the same kind of work upon the Saint John's River Bar.

Estimated cost of constructing a ship channel 15 *feet deep, at high water, from Nassau Inlet to Saint John's River, corresponding to a high-water depth of* 16 *feet on Nassau Bar, and inclusive of dredging in Saint John's River.*

To be removed.	Materials, and where located.	Price per cubic yard.	Amount.
Cub. yds.			
34, 400	On Nassau Bar, width 300 feet, and depth 16 feet, high water	$0 95	$32 680
1, 138, 000	Sand and loam in canals, 125 feet wide	32	364 160
414, 000	Sand and loam, in creeks	32	140 760
	Sand and loam in Saint John's River:		
14, 200	Near Dame's Point	32	4 544
17, 800	Near San Carlos Creek	32	5 696
	Total		547 840
	Add 10 per cent. for contingent expenses		54 784
	Total cost from Nassau Bar to Jacksonville		602 624

It is impossible to foresee with any close approximation to accuracy the extent to which the new creek-channel, after being once thoroughly established, would develop a tendency to fill up from natural causes, or the precise points at which such filling would take place. It might be reasonably apprehended, however, that occasional and perhaps frequent dredging would be necessary on the bar at the debouch of Saw-pit Creek into Nassau Sound, at the mouth of Hannah Mills' Creek on the Saint John's River, and where the tides meet between Saint John's River and Nassau Sound, and between Nassau Sound and Amelia River.

Upon the Nassau Bar, as an element of the shorter route, it would doubtless be necessary to dredge frequently.

GENERAL OBSERVATIONS.

The entire absence of soundings and other necessary information concerning all that portion of the route south of Nassau Sound, excepting three and three-eighths miles of Saw-pit Creek, covered by the Coast Survey chart, renders it impossible to submit an estimate for any other depth of inside channel than that proposed by the engineer who made the survey, and which I have assumed to be 15 feet high water, corresponding to a depth of 16 feet high water on Nassau Bar, reported to have been found to at the time of the survey.

But as the actual high-water depth upon that bar is only 14½ feet, which is 2 feet more than exists upon the Saint John's Bar in its natural condition, the questions which naturally arise, in considering the problem of improving the ocean approach to the Saint John's River, are the following:

1. What expenditure of money by the General Government do the interests repre-

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sented in that locality justify, presuming the expenditure to be judiciously made in the execution of some plan promising success?

2. Is it advisable to adopt any method of improvement involving more or less constant dredging upon an ocean bar, liable to fill up at any time, to the more or less serious detriment of commerce?

3. Can an inside channel from Nassau Sound to Saint John's River, corresponding to the natural, and therefore permanent, depth on Nassau Bar, be constructed at a justifiable cost, and will such answer the present and prospective demands of commerce?

With regard to the first point, it is my opinion that any expenditure, not exceeding say $180,000 to $200,000, that would secure a reliable water-approach to Jacksonville for vessels drawing 14 feet of water would be justified.

With regard to the second question, I am not in favor of placing much reliance upon artificial channels subjected to the direct action of the ocean waves, where any other practical means of relief can be controlled short of exorbitant cost.

The third question cannot be answered or intelligently discussed without more information upon the subject than I have been able to command.

It may be said, however, that the natural high-water depth of 14½ feet upon the Nassau Bar would doubtless be increased 6 to 9 inches by such frequent passage of steamers, and especially of tug-boats and propellers, as would result from the adoption of this channel of approach to the Saint John's River. Such is known to be the effect upon the Saint John's Bar and other shallow bars on the southern coast. I have little doubt that a practicable high-water depth of nearly, if not quite, 15 feet on the Nassau Bar would ensue from the selection of this entrance, and this would allow the passage of vessels drawing about 14 feet in ordinary weather.

The survey of Nassau Sound, now in progress, will most likely, when completed, indicate the practicability of reducing the length and construction cost of the inner passage by making a straight cut across Talbot Island in a northeasterly direction from the north end of Gunnison's Cut, intersecting the channel of Nassau Sound about one mile and a quarter below the mouth of Saw-pit Creek, and thereby avoiding two very sharp angles in the channel of the latter.

The question then, it would seem, turns upon the cost of constructing a ship-channel 14 feet deep at high water from Nassau Sound to the Saint John's River, for which there exists no *data*, that I am aware of, upon which a satisfactory estimate can be based.

I am informed that a Coast Survey party is now, or soon will be, engaged in completing their survey of this inside passage as far as Saint John's River. In reply to my inquiries upon this subject, a letter from the United States Coast Survey Office, dated at Washington, the 27th ultimo, states that "the chart of the inside passage from Fernandina to Saint John's River is not so far advanced that it is possible to say when it will be completed."

I judge that the completion of the work would not be hastened materially by the assumption of any portion of it by the Corps of Engineers, and I therefore make no recommendation in the matter at the present time further than to express the opinion that the definite determination of the question whether a ship-channel from Nassau Sound to Saint John's River, corresponding to the natural high water-depth on the Nassau Bar, can be constructed at a reasonable cost, should receive the earliest possible attention.

There are conflicting local interests bearing upon this subject, those centered at Jacksonville being opposed to those at Fernandina. The people of Jacksonville, in fear of becoming tributary to the prosperity of Fernandina, object to the longer inside passage, and advocate its termination at Nassau Sound. I append hereto a copy of a letter received from Mr. William P. Dockray, president of the Atlantic and Saint John's Dredge and Towing Company, and a copy of my reply.

A chart of the proposed inside passage accompanies this report, and the papers referred to me are returned herewith.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major of Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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APPENDIX Q.

ANNUAL REPORT OF MAJOR W. P. CRAIGHILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, September 7, 1872.

SIR: I have the honor to transmit herewith my annual report upon the works under my charge, for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

Q 1.

IMPROVEMENT OF THE SUSQUEHANNA RIVER BELOW HAVRE DE GRECA MARYLAND.

At the close of the year ending June 30, 1871, operations were in progress, under the authority granted to use the material of the old moveable deflector, and such money as might be available for the purpose, for the construction of a *fixed* wooden dike or deflector, to concentrate the flow of the river, as had been proposed and partially accomplished by the temporary movable structure built in the autumn of 1867. The dike was projected to consist of piles driven about 5 feet apart, braced by sloping piles behind them and bolted to them, the whole connected by strong double cap-pieces, between which 3-inch planks were to be closely driven, forming a nearly water-tight barrier. This work was carried to a length of 3,900 feet by the end of October, 1871, when operations were suspended.

As was anticipated, this structure, consisting entirely of wood, was somewhat injured by the ice of winter and the freshets of spring, but its advantageous influence has been clearly demonstrated, and the opinion has been confirmed as to the propriety of replacing it by a permanent structure, for which an appropriation of $50,000 is recommended.

The wooden deflector will be repaired as far as the limited available funds will permit.

The improvement is in the collection district of Baltimore, which is the nearest port of entry. It extends from opposite Point Concord Light to Spesutie Island.

The trade between Baltimore, Philadelphia, and New York, and the Susquehanna Valley to near its head, is interested in this work. The amount cannot be accurately ascertained.

Amount of revenue collected at Baltimore, as duties on imported merchandise, for the fiscal year was nearly $9,000,000 in coin.

Expended in year ending June 30, 1872	$7,469 06
Available for year ending June 30, 1873	6 30
Required for year ending June 30, 1874	50,000 00

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Q 2.

IMROVEMENT OF NORTHEAST RIVER, MARYLAND.

Under a call from Congress for information, an examination of this river was made in April, 1872, and a report submitted under date of April 8, 1872.

An appropriation of $10,000 was made June 10, 1872, which it is proposed to expend in 1872 in making a channel from a point about 4,500 feet from the town of Northeast to that town, about 60 feet wide at bottom, and 5 feet deep at mean low water, and if possible to extend it, with less width, to Alexander's mill, about 1,000 feet farther.

Northeast is in the collection district of Baltimore, but no record is kept of vessels arriving and departing. This is a thriving place and growing in importance.

There were no proposals called for during the year and no contracts or expenditures.

Available for year ending June 30, 1873, $10,000.

No further appropriation needed.

Q 3.

IMPROVEMENT OF THE ENTRANCE TO THE HARBOR OF BALTIMORE, IN THE PATAPSCO RIVER, CHESAPEAKE BAY.

On the 1st of July, 1871, the work of dredging in the Brewerton Channel was in progress under the contract of April 20, 1871, with Mr. Brainard, of Albany, New York. His engagement was for the removal of 150,000 cubic yards of material, and was nearly fulfilled June 30, 1872. Two of the city dredges, under the direction of the port-warden, were also at work in the same channel during a considerable part of the season of 1871. A contract was also made with Mr. Alanson Dodge, of Fulton, New York, for the removal of 100,000 cubic yards from the Brewerton Channel, and 60,000 yards from the lower channel, and work begun in September, 1871, continued with the usual interruption in winter during the fiscal year. His contract will be completed in 1872.

Proposals have been invited for the expenditure of the appropriation of June 10, 1872, of $100,000, and it is expected that much progress will be made during 1872. Not less than 300,000 yards should be removed with that sum.

The vast increase in the commercial importance of Baltimore, since the late civil war, and the great development of her trade, especially by steam with foreign ports, made the pressure so great for more rapid progress with the improvement than was possible from the use of the appropriation of the General Government, that the municipal authorities organized a board of improvement in the spring of 1872, and placed at their disposal $200,000 for immediate expenditure.

Five of the city dredges commenced work in June. A contract has been made by this board with Morris & Cummings, of New York, for removing 300,000 yards from the Brewerton Channel, at the average rate of 2,500 yards a day. A contract has also been made with Curtis & Fobes, of Portland, Maine, for removing, by May 1, 1873, 150,000 yards from the same channel. The intention is to have the width of the Brewerton Channel increased from 150 to 250 feet, and of the lower

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channel from 250 to 400 feet. The composition of the board is a sufficient evidence of the very great importance attached to the work. The mayor of the city, Hon. Joshua Vansant, is the chairman. The other members are Mr. John W. Garrett, president of the Baltimore and Ohio Railroad Company, and Mr. J. Hall Pleasant, chairman of the harbor committee of the Board of Trade of the city.

Range-lights have not yet been provided for the lower channel, but it is hoped they soon will be, as there was an appropriation made by Congress for that object at the last session.

It is my duty to call attention to the encroachments made by wharves, &c., upon the tidal reservoir pertaining to this harbor, both within and without the narrow entrance at Fort McHenry. Injurious changes in the regimen of the fluvial and tidal waters may be expected to result from what has already been done in this direction. I am not sufficiently versed in the law to know where the power resides to check such encroachments. It must, however, exist somewhere, and should be exercised to prevent further injury, if not to cause the removal of hurtful structures already standing.

For quite full statistical information as to the commerce of Baltimore courteously furnished by the Hon. J. L. Thomas, collector of the port, reference is requested to his letter of August 10, 1872, hereto attached, as well as to his letter of July 28, 1871, printed on pages 589–590 of the Report of Chief of Engineers, 1871.

Appropriated June 10, 1872	$100,000 00
Expended during year ending June 30, 1872	57,093 09
Available for year ending June 30, 1873	134,916 91
Required for year ending June 30, 1874	200,000 00

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Abstract of bids received in answer to advertisement of June 30, 1871, for dredging in Brewerton and Craighill Channels, Patapsco River, opened at 12.10 p. m., July 31, 1871.

No.	Names.	Address.	Nature of bid—dredging.	Machinery.	Price.	Time.	Remarks.
1	Hayden, Carkin & Co.	Chicago.....	Brewerton ..	Clam-shell	35 cents per cubic yard.....	15th Sept., 1871, to 1st July, 1872.	700 to 1,000 yards daily. Bid for whole.
			Craighill....				
2	Alanson Dodge	Fulton, N. Y	Brewerton ..	Osgood ..	33 cents per cubic yard.....	1st Sept., 1871, to 1st June, 1872..	Measured in scows. Dredge 800 yards per day.
			Craighill....		37 cents per cubic yard.....		
3	G. H. Ferris	Brooklyn ...	Brewerton ..	.....	*33 cents for first 10,000 yards.	1st Sept., 1871, to 31st Dec., 1872.	
			Craighill....		38 cents per cubic yard.....		

* Beginning at upper end of channel, to be increased by 1 cent after completion of each 10,000 yards, *i. e.*, for first 10,000 yards, 33 cents; second, 34 cents; third, 35 cents, and so on.

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CUSTOM-HOUSE, BALTIMORE, MARYLAND,
Collector's Office, August 10, 1872.

SIR: In compliance with the request contained in your communication of the 2d instant, to inform you what amount of revenue was collected at the port of Baltimore during the year ended June 30, 1872, and to furnish you with any other information appertaining thereto that I may supply, I have to communicate in reply to your first query, that the duties collected at this port on imported merchandise from the 1st July, 1871, to June 30, 1872, in coin, amount to $8,728,183.03. Receipts from all sources, $8,857,231.81.

Permit the remark at this point, that the amount of duties collected for the period named, absolutely considered, may not be taken as an index to show either the extent or the *status* of the commerce of this port, for the reasons herein stated. For instance, the sum above named was collected under the reduced rates of tariff, under the act of July 14, 1870, and before the fiscal year expired the acts of May 1, 1872, and June 6, were passed, the former of which wholly repealed the duties on coffee, and the latter made material reductions in the tariff rates on various articles of foreign importation.

The reduction of 2 cents per pound on coffee, under the act of 1870, materially reduced the revenue at this port, and by an estimate made in a statement to you on the 5th of January last, it appeared that the revenue receipts of this port, on coffee alone, were lessened for the year 1871 to the extent of about $3,000,000. And although the last tariff acts did not go into operation until after the close of the fiscal year, they have had the effect to lessen the receipts for the period named, in this way. Importers warehoused nearly all the coffee that was imported for some time before the 1st of July, in order to get it admitted free of duty. Therefore, much of the coffee imported during the fiscal year named was withdrawn thereafter free of duty, and to that extent the receipts of that year are greatly lessened. The same course was pursued by importers in reference to other articles upon which a reduction was made in the tariff of June 6, and the goods so warehoused were not withdrawn until the 1st of August ensuing.

The action of the merchants in warehousing coffee and other foreign commodities, in order to get the benefit of the reduced rate of tariff, estopped, to a great extent, the operations of trade in other articles of foreign merchandise, and the latter-named were, also, largely warehoused, and were not withdrawn until after the fiscal year named had expired, which also had the effect to decrease the receipt of duties for that year.

The fact, in addition to the causes referred to, is also to be considered, that this port is a heavy coffee and sugar market, and these articles constitute its chief importations, and therefore the tariff reductions operated to lessen receipts of duties at this port very greatly.

The duty alone on coffee for the calendar year 1871, at the rate of 5 cents per pound, would have amounted to between $10,000,000 and $11,000,000, as shown in the former statement furnished you of July 5, 1871.

For the causes stated, it is apparent that the revenue collected for the period named does not of itself afford a basis by which to judge of the extent of commerce, but it may be better arrived at by comparison.

Under the old tariff rates (which applied to at least one-half of the preceding fiscal year) there were collected at this port for the fiscal year ended June 30, 1871	$8,892,528 98
For the fiscal year ended June 30, 1872	8,728,183 03
Showing a deficiency of	164,345 95

It will be seen by this comparison that, notwithstanding the causes adverted to as operating materially to reduce the amount of duties collected, the revenue of the last fiscal year is not far short of what it was the previous year, clearly showing a steady and marked increase in the foreign commerce of this port; and that while there has been enlarged importations in the coffee and sugar trade, the results of which do not appear in the amount of revenue collected, there has been an evident increase of importations in other articles of foreign growth and manufacture, the duties collected on which have nearly supplied the deficiency of revenue caused by reduction of tariff rates on other articles, and, especially, on coffee and sugar, which latter articles afford the chief sources of revenue at this port.

It should be borne in mind, however, that, although coffee yields no revenue to the Government, it is an article of merchandise largely imported into this port, and the trade therein is steadily and greatly improving, thereby enlarging the commerce of Baltimore, and requiring the same facilities of harbor accommodations therefor as though it continued a source of revenue.

You may not regard it as inappropriate for me to observe, at this point, that, while it is well understood throughout the country that the central position of this port, with its growing facilities for quick inland transportation, commands and invites trade with

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all sections of the country, it is subjected to serious drawback because of its want of sufficient depth of water at the entrance of its harbor. This fact is a source of embarrassment and complaint, and, as has been stated to you in my former communication, vessels drawing heavily at times cannot make their landing, and have to be lightened below, under the supervision of a discharging officer detailed for that purpose by this office.

Following in order with the above is an exhibit of the number of vessels arriving from foreign countries, with dutiable merchandise, for the last two preceding fiscal years, as follows:

	Vessels.
Year ending June 30, 1871	769
Year ending June 30, 1872	805
Increase during 1872	36

This exhibit does not afford a fair test of the increase of vessels arriving, with foreign dutiable merchandise, because of the period of time in which the arrivals occurred. As an illustration of this statement take the two preceding calendar years of 1870 and 1871, and it appears that in—

1870 there arrived vessels with dutiable cargoes	660
1871 there arrived vessels with dutiable cargoes	813
Showing an increase in favor of 1871 of	153
1870, vessels arrived with undutiable cargoes	74
1871, vessels arrived with undutiable cargoes	39
Showing a decrease during 1871 of	35
Excess of arrivals with cargoes dutiable and undutiable for 1871 over 1870	118

The value of foreign importations and domestic exportations will, perhaps, furnish a more reliable test of the commerce of Baltimore, and more nearly affords an answer to your question, "What amount of commerce would be benefited by the further improvement of the entrance of the harbor?"

Value of foreign imports.

For the fiscal year ending June 30, 1871	$24,672,871
For the fiscal year ending June 30, 1872	28,836,305
Showing increase during 1872 of	4,163,434

Value of domestic exports.

For the fiscal year ending June 30, 1871	$15,037,855
For the fiscal year ending June 30, 1872	18,325,321
Showing increase during 1872 of	3,287,466

Of the value of goods shipped and arriving coastwise I am unable to give you any information, as no statistics of that character are required to be kept in form at this office. It may be premised, however, from the extent of the coastwise trade, that it amounts to a considerable sum in value.

To your query, "as to what amount of navigation would be benefited by the further improvement of the entrance to the harbor," you are furnished with the following exhibit, embracing comparisons of the number of vessels, their nationality and tonnage; arrivals from, and departures to, foreign countries; and arrivals and departures coastwise, for the two last-preceding fiscal years:

Coastwise arrivals, all nationalities, mainly American.

	Vessels.	Tonnage.
For the fiscal year 1871	1,747	1,159,726
For the fiscal year 1872	1,757	1,214,026
Showing increase of tonnage during 1872 of		54,300

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Coastwise clearances.

	Vessels.	Tonnage.
For the fiscal year 1871	2,115	1,413,832
For the fiscal year 1872	2,172	1,440,796
Showing increase of tonnage during 1872 of		26,964

American vessels arriving from foreign ports.

	Tons.
For the fiscal year 1871	130,147
For the fiscal year 1872	118,342
Show decrease of tonnage during 1872	11,805

Foreign vessels arriving from foreign countries.

	Tons.
For the fiscal year 1871	185,458
For the fiscal year 1872	249,794
Showing increase during 1872	64,336

American vessels cleared for foreign countries.

	Vessels.	Tonnage.
For the fiscal year 1871	285	97,544
For the fiscal year 1872	276	92,286
Showing decrease during 1872 of	9	5,258

Foreign vessels cleared for foreign countries.

	Vessels.	Tonnage.
For the fiscal year 1871	401	167,329
For the fiscal year 1872	471	264,331
Showing increase during 1872 of	70	97,002

Total amount of tonnage of vessels, American and foreign, arriving at Baltimore from foreign countries, and departing thence to foreign countries, also arriving and departing coastwise.

	Tonnage.
For fiscal year ending June 30, 1871	3,154,0[illegible]
For fiscal year ending June 30, 1872	3,379,5[illegible]
Showing increase during 1872	225,53[illegible]

In addition to the amount of tonnage traversing the harbor of this port, there is a large amount of which there is no record. As stated to you in my former report, many vessels arrive and depart, coastwise, that are not required by law to report at the custom-house.

The registered outstanding tonnage of this district amounts to	142,613.09
Number of registered, enrolled, and licensed vessels comprising said amount of tonnage is	1,59[illegible]
The receipts for tonnage during the fiscal year of 1872 amount to	$34,05[illegible]

The act of July 14, 1870, restricts the collection of tonnage to certain cases, notwithstanding which, the receipts have latterly increased.

In view of the fact that you inquire relative to information promotive of the general interests of the country, as well as the local interests of this port, by the further improvement of the entrance to the harbor of Baltimore, it may not, therefore, be regarded as irrelevant to state that the foreign line of steamships (North German Lloyd) between Baltimore and Bremen, via Southampton, still maintains a vigorous existence, and has proved a successful enterprise. This line comprises four fine vessels, averaging 2,3[illegible] tons burden, and there is a strong probability of other vessels being added to that line.

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The Allan line of steamships have four splendid vessels running between here and Liverpool. The introduction of this line has also been a success.

It is in the case of these vessels that difficulties at times is experienced in approaching the harbor.

If my information is correct, there is sufficient business to justify additions to this line and a willingness on the part of the owners to make the increase, but they are deterred because of the want of depth of water as aforementioned. Much of the merchandise imported by these lines go to adjacent and western cities, and there can be no doubt that heavy importations would be made, by way of these lines, through Baltimore, to the West, if more steamship facilities were afforded.

The sea-going line of steamers between here and Boston, and other localities, are also in successful operation.

Merchandise is shipped to this port from Boston for western cities, and freights from similar sources are shipped in return to Boston.

The southern sea-going coastwise lines bring cotton to this port, a portion of which is shipped to Europe by the foreign lines.

The inland and bay lines continue, as formerly, and many of the steamers so engaged are of large burden. These steamers bring tobacco in large quantities to this port, much of which is shipped to European markets by the foreign lines.

It is therefore fair to maintain that the improvement of the harbor is promotive of the general as well as the local interests of the city, and that the affinities of trade subsisting between Baltimore and throughout the country, and especially the West, make that improvement one of national, as well as local, concern.

Your impression in reference to the ports of Cambridge, Queenstown, Havre de Grace, Waterton, and Northeast being within the collection district of Baltimore is correct as to all the places named; but none of them except Havre de Grace are ports; the latter named being a port of delivery only.

I am unable to give you the amount of registered outstanding tonnage at Havre de Grace, it being consolidated with the tonnage of this district. It amounts to a very respectable sum, however, and is confined mainly to schooners and vessels of moderate tonnage, and largely to canal-boats. Foreign goods have seldom been delivered at that place.

The nature of the cargoes carried by such vessels as hail from that port consist chiefly of lumber and coal, and mostly comes to Baltimore for consumption, and to adjacent places.

As the nature of the trade does not require, under the law, the vessels to enter and clear, it is impracticable to get at the amount of tonnage of vessels which enter and depart from that harbor, but as the place is a thriving one, and well situated for trade, it is doubtless very respectable.

The other harbors named are neither ports of entry or delivery, and no record is kept of vessels arriving and departing therefrom. There is therefore no means of knowing what amount of tonnage enters the waters of those places. Some of them are places of importance to this city, and each maintains a growing trade therewith. Lines of steamers run between here and them, and their products find a destination at this port and in other sections of the country.

I am, very respectfully,

BALTIS H. KENNARD,
Special Deputy Collector.

Colonel W. P. CRAIGHILL.
United States Engineers, Baltimore, Maryland.

Q 4.

IMPROVEMENT OF THE WICOMICO RIVER, NEAR SALISBURY, MARYLAND.

A survey of a portion of this river was made early in 1871, and report submitted.

It was found that the improvement needed was the opening of a channel by dredging, from the existing 7-foot water to the bridge, about 75 feet in width and 7 feet in depth at mean low water, the cost to be about $20,000, at present prices. The inhabitants agreed to erect what dikes might be deemed necessary.

An appropriation of $5,000 was made June 10, 1872, which it is proposed to expend in 1872 in making a channel about 25 feet in width, and 7 feet in depth at low water.

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The Wicomico is in the collection district of Baltimore, at which port the revenue in coin was nearly $9,000,000. For a description of the locality, as well as for indications as to present and prospective commercial importance, reference is requested to the report printed on pages 621 to 624 of the report of the Chief of Engineers, 1871.

There were no proposals called for during the year, and no contracts made.

Expended during the year ending June 30, 1872	.....
Available for year ending June 30, 1873	$5,000 00
Required to complete according to estimate, which may be expended in year June 30, 1874	15,000 00

Q 5.

IMPROVEMENT OF WORTON HARBOR, MARYLAND.

Under a call from Congress for information, an examination of this place was made in April, 1872, and a report submitted under date of April 18, 1872.

An appropriation of $12,000 was made June 10, 1872, which it is proposed to expend in 1872 in making a channel from the head of Worton Creek to the confluence of Worton and Tim's Creeks, a distance of about 2,000 feet, about 100 feet wide at bottom, and 7 feet deep at mean low water.

Worton is in the collection-district of Baltimore, but no record is kept of vessels arriving and departing. This is a thriving place, and growing in importance.

There were no proposals called for during the year, and no contracts or expenditures made.

Available for year ending June 30, 1873, $12,000.

No further appropriation needed.

Q 6.

IMPROVEMENT OF QUEENSTOWN HARBOR, MARYLAND.

At the close of the fiscal year ending June 30, 1871, Mr. John W. Parks, under a contract dated April 26, 1871, was engaged in dredging a channel in Queenstown Creek to a depth of 8 feet at mean low water. The appropriation was exhausted and the work of dredging came to a close, July 25, 1871. One cut of the required depth, and of a width of 25 feet, was completed, and a second cut nearly so.

An appropriation of $6,000 having been made by the act approved June 10, 1872, it is proposed to expend it in increasing the width of the channel and giving a greater capacity to the harbor. This improvement will probably be completed before the close of 1872.

Queenstown is situated in the collection-district of Baltimore, which is the nearest port of entry. The revenue at Baltimore, in coin, was nearly $9,000,000.

For a description of the harbor, as well as for indications of its present and prospective commercial importance, reference is requested to the report printed on pages 613 and 614 of the annual report of the Chief of Engineers, 1871.

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There were no proposals called for during the fiscal year, and no contracts made.

Expended during the year ending June 30, 1872	$2,440 80
Available for year ending June 30, 1873	5,924 00
Required for year ending June 30, 1874	

Q 7.

IMPROVEMENT OF THE HARBOR OF CAMBRIDGE, MARYLAND.

At the close of the year ending June 30, 1871, Mr. Ferris, of Brooklyn, was engaged in dredging, under a contract dated April 26, 1871. The appropriation was exhausted about the end of August, 1871, when the work of dredging came to a close.

A channel 100 feet in width and 9 feet in depth at low water, was made from the Choptank River to the mouth of the creek leading into the inner basin. A channel of the same depth and 50 feet in width was carried into the inner basin, and some excavation of the same depth was done in the inner basin, to facilitate the use of the railroad-wharf. The remainder of the appropriation was expended in improving the facilities for the use of the steamboat-wharf in the outer harbor and in bettering the entrance to the inner basin.

An appropriation of $10,000 having been made by the act approved June 10, 1872, it is proposed to expend it in improving the outer harbor and inner basin, the entrance to the former, and the channel between them. The improvement will probably be completed in 1872.

Cambridge is situated in the collection-district of Baltimore, which is the nearest port of entry. The revenue at Baltimore was nearly $9,000,000 in coin. For a description of the harbor, as well as for indications of its present and prospective commercial importance, reference is requested to the reports printed on pages 615–620 of the annual report of the Chief of Engineers, 1871.

There were no proposals called for during the fiscal year, and no contracts made.

Expended during the year ending June 30, 1872	$7,602 43
Available for year ending June 30, 1873	9,923 00
Required for year ending June 30, 1874	

Q 8.

IMPROVEMENT OF THE POTOMAC RIVER.

At the close of the year ending June 30, 1871, Mr. N. G. Dodge, under a contract dated December 6, 1870, was engaged in dredging in the Virginia Channel, between the Long Bridge and Georgetown, with the object of making a channel 200 feet in width and 15 feet in depth at low water. The material removed was required to be deposited near the causeway behind Analostan Island, with a view of preventing its return into the channel. The work was completed about the middle of December, 1871.

The examination of this channel, made in April, 1872, by Captain C. B. Phillips, Corps of Engineers, indicated that up to that time it continued in good condition.

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Having been informed that, under authority of an act of Congress, a commission have under consideration the subject of the further improvement of the river, it seems unbecoming in me to discuss it further than to call attention to my report printed in the annual report of the Chief of Engineers, 1871, pages 591 to 595, and to quote from it a single paragraph:

It would seem proper to turn attention now to the improvement of the Washington Channel below Long Bridge, for which an appropriation of $50,000 is recommended. The opening of the cut proposed from Maryland draw of Long Bridge to Easby's wharf, will cost not less than $100,000. For the removal of rocks near Georgetown $10,000 is needed.

Expended in year ending June 30, 1872	$22,880 34
Available for year ending June 30, 1873	550 62
Asked for year ending June 30, 1874	160,000 00

Q 9.

IMPROVEMENT OF ACCOTINK CREEK, VIRGINIA.

A survey of this creek was directed in the appropriation bill of March 3, 1871, and was executed in June and July, 1871, under the immediate supervision of Captain C. B. Phillips, Corps of Engineers. A report was made January 22, 1872.

An estimate was submitted amounting to $19,000 for giving a channel up to the village of Accotink, 40 feet wide at bottom and 5 feet deep at mean low water.

An appropriation of $5,000 was made June 10, 1872, which it is proposed to expend in 1872 in making a channel to the town of Accotink, about 2½ feet deep at mean low water, and as wide as the funds will permit.

Accotink is in the collection district of Alexandria. For a description of the locality, as well as for indications of its present and prospective commercial importance, reference is requested to the report of January 22, 1872, which was printed in Ex. Doc. No. 35, Senate, Forty-second Congress, second session.

There were no proposals called for during the fiscal year, and no contracts made.

Expended during year ending June 30, 1872	.....
Available for year ending June 30, 1873	$5,000 00
Required to complete, according to estimate, which may be expended in year ending June 30, 1874	14,000 00

Q 10.

IMPROVEMENT OF AQUIA CREEK, VIRGINIA.

A survey of this creek was directed in the appropriation bill of March, 1871, and was executed June and July, 1871, under the immediate supervision of Captain C. B. Phillips, Corps of Engineers.

A report was made January 22, 1872, and an estimate was submitted, amounting to $18,000, for giving a channel from the 6-foot water near the mouth of the creek to the "narrows," about 40 feet in width at bottom and 6 feet deep at mean low water.

An appropriation of $1,500 was made June 10, 1872, which it is pro-

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posed to expend in 1872 in making a channel from the draw in the railroad-bridge up toward the "narrows" as far as practicable, 20 feet wide at bottom and 4 feet deep at mean low water.

Aquia is in the collection-district of Alexandria. For a description of this locality, as well as for indications of its present and prospective commercial importance, reference is requested to the report of January 22, 1872, which was printed in Ex. Doc. No. 35, Senate, Forty-second Congress, second session.

There were no proposals called for during the fiscal year, and no contracts made.

Expended during year ending June 30, 1872	$———
Available for year ending June 30, 1872	1,500 00
Required to complete, according to estimate, which may be expended in year ending June 30, 1874	16,500 00

Q 11.

IMPROVEMENT OF THE RAPPAHANNOCK RIVER BELOW FREDERICKSBURG.

At the close of the year ending June 30, 1871, Mr. G. H. Ferris, under a contract dated May 9, 1871, was engaged in dredging on the Spottswood Bar. Dredging was continued until its suspension by ice about the middle of December, 1871. Channels had been opened through the Spottswood and Fredericksburg Bars, each 70 feet in width, and 8 feet deep at low water. This improvement gave at once the obvious advantage of admitting to the wharves of the town of Fredericksburg vessels of greater draught of water, while permitting the regular steamers already plying to arrive and depart at any stage of the tide, instead of being restricted to doing so at the variable hour of high water.

Several wrecks, obstructions to navigation, and injuriously affecting the regimen of the river, have also been removed. One, near the wharves of the city of Fredericksburg, under a contract with Mr. R. D. Minor, of Richmond, Virginia; one at Spottswood Bar, under an agreement with Mr. B. Maillefert, of New York. The following, under a contract with Hebrew & Asserson, of Norfolk, Virginia: one schooner at Piscatwa Creek; one schooner at Urbana; two steamers at Mill Creek; one light-ship at Lowrie's Point.

A report on the improvement of the river was made January 26, 1871, which was printed in Ex. Doc. No. 60, part 3, House of Representatives, Forty-first Congress, third session. This report indicated that the principal obstructions to navigation consisted of bars, formed by alluvial deposits, and, in a few cases, the remains of wrecks sunk for military purposes during the war. It was proposed therein to excavate a channel 100 feet wide and 10 feet deep at low water, by dredging through the shoals; to remove the wrecks by blasting; and to add to the permanence of the work by training dikes at various points. The estimated cost of the whole was $83,360.

By the act of March 3, 1871, the sum of $15,000 was appropriated for the river. Owing to the limited amount of the appropriation, the work was confined to the operations indicated above, which have given good results, but they will not be permanent without the application of an additional sum, in conformity with the plan and estimate already referred to. It is believed that if that plan be carried out, an annual

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appropriation of $5,000 will be sufficient to keep the improvement in good condition.

By the act of June 10, 1872, an additional appropriation of $15,000 was made for the Rappahannock, which it is proposed to apply, in connection with the balance from the previous appropriation, to extending, by dredging, the channels already excavated near the city of Fredericksburg; to building dikes in the same vicinity, with the double object of contracting the water-way and increasing the flow through the dredged channel, and providing a receptacle behind which to deposit material removed from the channel; to rectifying the mouths of Deep and Hazel Runs, in order to give them a better entrance into the river, and to prevent hurtful deposition from them in the channel; and probably to the removal of some other wrecks near the city.

It will require about $65,000 to complete the whole work as originally intended, and that amount could be profitably expended next season.

The trade and commerce to be benefited by this improvement embrace the coastwise and foreign trade in grain, tobacco, and cotton and woolen manufactured goods. The river drains a large and fertile section of country, and a slackwater navigation and canal make it the proper outlet for one of the richest farming regions of Virginia.

The work is located in the collection-district of Tappahannock. It extends from Fredericksburg, at the head of navigation on the Rappahannock, to Tappahannock, about sixty miles below.

Appropriated June 10, 1872	$15,000 00
Expended in fiscal year ending June 30, 1872	11,263 03
Available for year ending June 30, 1873	18,226 10
Required for year ending June 30, 1874	65,000 00

Q 12.

IMPROVEMENT OF THE JAMES RIVER, VIRGINIA.

On the 30th of June, 1871, Mr. Maillefert was engaged, under a second contract, in removing additional wrecks and obstructions from the river, his only compensation being the proceeds of his operations. The removals were as follows:

At Drury's Bluff part of the steamer Jamestown, part of the iron-clad steamer Virginia, iron-clad steamer Fredericksburgh, steamer Beaufort, schooner Wythe, brig Marcus, and parts of three cribs filled with stone. At Wilton 40 to 60 piles, remains of a bridge, and part of a steamer. Mr. Maillefert's operations have been very successful, and have resulted in restoring the fine channel existing by nature at Drury's Bluff.

The Dutch Gap Cut-off was opened to the use of navigators early in January, 1872, its width being about 135 feet at the water-line, and its depth sufficient for vessels of the largest class trading to Richmond. A land-slide on the southern bank of the cut-off occurred in March, 1872, with reference to which a special report was made March 25, 1872, as follows:

UNITED STATES ENGINEER OFFICE.
Baltimore, Maryland, March 25, 1872.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.:

GENERAL: In order to avoid misapprehension which might arise, from information derived from unofficial sources, I have the honor to report that a slide in the southern

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bank of the Dutch Gap Cut-off took place last week. It is not of great extent nor likely to impede navigation seriously, or involve the United States in much, if any, additional expense.

In justice to myself, I will simply say that the slide occurred at a place which I considered dangerous, but it was left standing at the request of the city engineer for the James River.

He now comes forward very frankly and admits his error of judgment, and proposes to remove the *débris* at the expense of the city, to which I shall, of course, make no objection. It is not improbable other slides of small extent may occur, but I believe the cheapest and best course will be to leave the slopes to be regulated by the hand of nature, and remove the material when necessary, as it falls into the cut.

The city engineer's opinion as to the expected stability of the slope which has fallen, was founded upon a consideration of the fact that it has been standing since the operations of General Butler at that point in the late war of the rebellion, (nearly ten years,) and was not steeper than natural slopes on the river in the vicinity, the materials being apparently the same.

The winter on the James River has been an unusually severe one, subjecting this slope to an extraordinary trial, but its yielding is possibly to be accounted for by supposing that its integrity was injured by the explosion of blasts of powder, freely used (I am informed) in the operations of General Butler, already referred to.

No further slides have since occurred, and although the *debris* is not yet removed, (but soon will be,) the cut-off is still the main thoroughfare, and capable of use readily by the largest steamers and sailing-vessels on the river.

Under their contract for opening a channel through the Rocketts Reef, near the city of Richmond, 125 feet wide and 18 feet deep at high water, Kalmback & Barton continued their operations until the latter part of February, but in a feeble and entirely unsatisfactory manner. No useful result was attained by them, and it became necessary to annul the contract on the 23d of February, 1872. Arrangements were at once made for procuring the necessary machinery and apparatus for executing the work under the immediate supervision of the resident engineer. On the 30th of June, 1872, the work was progressing satisfactorily, with every prospect of speedily opening the channel through this reef, which has been the most dangerous natural obstruction to the navigation of the river since Richmond has had any commercial importance.

The committee on the part of the city have zealously co-operated with the United States engineer in the improvement of the river. A very important change for the better in their mode of disposing of material dredged from the channel has been made at the suggestion of the United States engineer. This change consisted in giving up the course hitherto pursued of dumping the dredged material on flats and shoals near the banks of the stream, from which much or all of it found its way back into the channel. Now, substantial but cheap dikes are built at suitable points, behind which the dredged material is placed. Besides affording excellent receptacles for this material, the dikes permit the advantageous rectification of the banks and the contraction of the water-way in some places where such modifications were needed.

Examinations were made last winter of Harrison's Bar and the Goose Hill Flats. Ultimately some dredging will be needed at both these points, to give the depth of 15 feet at low water which is aimed to be carried to Richmond. These bars have now more water upon them than some of the others nearer the city.

Appropriated June 10, 1872	$50,000 00
Expended in year ending June 30, 1872	42,417 64
Available for year ending June 30, 1873	75,413 74
Required for year ending June 30 1874	100,000 00

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Q 13.

IMPROVEMENT OF THE APPOMATTOX RIVER, VIRGINIA.

On the 1st of July, 1871, dredging was in progress by the authorities of the city of Petersburg, and at their expense, in continuing the opening of the cut through the Puddledock Marsh, which was a part of the plan of improvement of Mr. H. D. Bird. This dredging was continued during July and August, 1871. On the 31st of August, 1871, a contract was made with Mr. G. H. Ferris, of Brooklyn, for the removal of 150,000 cubic yards of material from the south channel of the river, in forming a channel about 60 feet wide at bottom, and about 10 feet deep at low water. This contract was very satisfactorily completed within the fiscal year.

It having been decided that the cut through the Puddledock Marsh should be completed by the United States, the operations of the city were suspended and a contract made with Mr. B. S. Burch, November 21, 1871, for the removal of 50,000 yards of material from that cut, the channel to be of about the same dimensions as that in the south channel, of which, when completed, it will form a continuation. Mr. Burch's progress has been slow and vexatious, but the results have been good, owing to the watchfulness and diligence exercised by the resident engineer and the inspector. This contract will be concluded early in the autumn of 1872.

The material from the south channel has been towed off and dumped in the deep water below the Point of Rocks.

The material from Puddledock Cut could not be towed away, owing to the impossibility of using dumping-scows. It has therefore been deposited in the marsh near by, but at a distance from the cut sufficiently great, it is believed, to prevent its return even under the influence of freshets.

An appropriation of $40,000 was made June 10, 1872, which it is proposed to expend in completing the cut through the south channel and Puddledock Marsh, and in turning the river through this new channel. It is expected that this result will be attained before June 30, 1873.

This channel is of the minimum width, which should be increased. The river also needs improvement at the bars between Puddledock Marsh and the city of Petersburg.

Appropriated June 10, 1872	$40,000 00
Expended in year ending June 30, 1872	41,586 7
Available for year ending June 30, 1873	47,706 00
Required for year ending June 30, 1874	75,000 00

Appended is the report of Mr. H. D. Bird, assistant engineer in charge at Petersburg.

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Abstract of proposals for dredging, &c., in Puddledock Marsh, Appomattox River, opened August 21, 1871.

No.	Names of bidders.	Residence.	Compensation.	Time of beginning.	Time of ending.
2	N. G. Dodge & Bros...	Georgetown, D. C.	39 cts. per cubic yard..	Nov. 1, 1871	July 1, 1872
6	S. F. Shelbourne.....	New York, N. Y..	48.8 cts. per cubic yard.	In a reasonable time.	June 1, 1872
7	F. H. Smith	New York, N. Y..	32 cts. per cubic foot*..	Not specified	Not specified.
9	Hayden, Carkin & Co.	Chicago, Ill.....	49 cts. per cubic yard..	Oct. 1, 1871	May 1, 1872
10	James Caldwell.....	Fulton, N. Y.....	34 cts. per cubic yard..	Oct. 1, 1871	July 1, 1872
13	G. H. Ferris	Brooklyn, N. Y....	53 cts. per cubic yard..	Sept. 15, 1871	May 15, 1872
15	B. S. Burch & Co.....	Petersburg, Va..-	45 cts. per cubic yard..	Oct. 1, 1871	Oct. 1, 1872
17	William Richardson ..	Buffalo, N. Y	45 cts. per cubic yard..	Oct. 1, 1871	July 1, 1872
18	E. T. Bangs	Fayetteville, N. Y.	74 cts. per cubic yard..	Oct. 1, 1871	March 1, 1872
20	C. P. Morse & Co.....	Oswego, N. Y.....	48 cts. per cubic yard..	Oct. 1, 1871	July 1, 1872
22	O'Brien & Howlet.....	Richmond, Va	16 cts. per cubic yard..	Sept. 1, 1871	March 1, 1872
23	Daniel Lyon ‡.....	Petersburg, Va..-	43 cts. per cubic yard..	Oct. 1, 1871	Oct. 1, 1872

* Price probably intended to be per cubic yard; will accept contract on one or both jobs.
† The wording of this bid is ambiguous—needs investigation.
‡ The job in Puddledock not wanted unless that in south channel is also given. Material to be measured in buckets of dredge..

Abstract of proposals for dredging in south channel, Appomattox River, opened August 21, 1871.

No.	Names of bidders.	Residence.	Compensation.	Time of beginning.	Time of completion.
1	John H. Tennet*.....	Albany, N. Y.....	19.45 cts. per cubic yard.	Nov. 15, 1871	May 15, 1872
2	N. G. Dodge & Bros...	Georgetown, D. C	23¼ cts. per cubic yard	Nov. 1, 1871	July 1, 1872
3	American Dredging Co.	Philadelphia, Pa..	30 cts. per cubic yard..	Oct. 1, 1871	April 1, 1872
4	Francis H. Smith.....	New York, N. Y...	28 cts. per cubic foot§..	Not specified.	Not specified.
5	S. H. Shelbourne	New York, N. Y..	24.40 cts. per cubic yard.	Within a reasonable time.	April 1, 1872
8	James Caldwell	Fulton, N. Y.....	26 cts. per cubic yard..	Oct. 1, 1871	July 1, 1872
9	Hayden, Carkin & Co†	Chicago, Ill	24¾ cts. per cubic yard	Oct. 1, 1871	May 1, 1872
11	William H. Mael.....	Oswego, N. Y	20 cts. per cubic yard...	When requir'd	When requir'd
12	G. H. Ferris.....	Brooklyn, N. Y ...	18¾ cts. per cubic yard.	Sept. 15, 1871	May 15, 1872
14	B. S. Burch & Co.....	Petersburg, Va..-	30 cts. per cubic yard..	Oct. 1, 1871	Oct. 1, 1872
16	William Richardson...	Buffalo, N. Y.....	27 cts. per cubic yard..	Oct. 1, 1871	Sept. 1, 1872
19	E. T. Bangs.....	Fayetteville, N. Y.	23 cts. per cubic yard..	Oct. 1, 1871	Oct. 1, 1872
21	C. P. Morse & Co.....	Oswego, N. Y.....	26 cts. per cubic yard..	Oct. 1, 1871	July 1, 1872
24	Daniel Lyon ‡	Petersburg, Va	26 cts. per cubic yard..	Oct. 1, 1871	Oct. 1, 1872

* Not to include rock; to be measured in scow. § Probably intended to be per cubic yard.
† Will accept contract on one or both jobs.
‡ Will not take this job unless the Puddledock job is also awarded to him.

PETERSBURG, VIRGINIA, *September* 5, 1872.

SIR: I have the honor to acknowledge the receipt of your letter of the 2d ultimo, requesting me to obtain such reliable information in regard to Petersburg as will show the amount of commerce and other business that would be benefited by the improvement of the Appomattox River up to the city, and also any information showing the importance of this improvement to the general interests of the country. In reply I beg leave to submit the following report, which I have made out from the best information I could obtain.

1. The portion of the Appomattox River under improvement is in the collection-district of Petersburg.

2. The custom-house duties paid the Government for the last twelve months were		$872,441 58
To which I will add amount of internal revenue paid on tobacco	$505,017 43	
On tobacco in bond	1,676,871 24	
On spirits	90,015 64	
On other articles	62,887 97	
		2,334,792 28
Post-office postage-stamps sold		16,785 74
Total paid		2,424,019 60

3. Population of Petersburg, 18,950.

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4. Valuation of property:		
Real estate		$5,189,000 00
Personal		3,247,000 00
Total amount		8,436,000 00
4. Taxes paid:		
State		$61,000 00
Municipal		151,000 00
Water-rents		11,700 00
Gas		40,000 00
Total amount		263,700 00
5. Tonnage of the river:		
225 trips of steamboats up and down; 153 sailing-vessels		14,800
6. Tonnage of the railroads:		
Petersburg and Weldon and branch, 81 miles		52,844
Petersburg and Richmond, 23 miles		75,270
Southside, 133 miles, through	100,792	
Southside, way	73,252	
		174,044
Norfolk and Petersburg, 80 miles, through	90,617	
Norfolk and Petersburg, way	39,637	
		130,254
Total tonnage		432,412
7. Agricultural products sold in Petersburg:		
30,000 bales cotton, value		$2,565,000 00
11,000 hogsheads tobacco, 3,500,000 pounds loose		2,200,000 00
650,000 bushels wheat		1,170,000 00
300,000 bushels corn		240,000 00
100,000 bushels pea-nuts		150,000 00
2,000,000 pounds sumac		25,000 00
Oats, hay, &c		55,000 00
Total amount		6,405,000 00
8. Merchandise, &c., sold in Petersburg:		
Groceries		$5,000,000 00
Dry-goods		1,500,000 00
Clothing		350,000 00
Hardware, stoves, and tin-ware		350,000 00
Boots and shoes, and hats and caps		575,000 00
Drugs, medicines, and paints		150,000 00
Crockery and stone ware		75,000 00
Iron and steel		50,000 00
Hides and leather		75,000 00
Books, stationery, and musical instruments		60,000 00
Fertilizers		150,000 00
Lumber		150,000 00
Coal and wood		215,500 00
Miscellaneous		105,500 00
Total value merchandise, &c., sold		8,806,000 00
8. Manufactories:		
7 cotton-factories running 25,000 spindles; value of products		$950,000 00
20 tobacco-factories, value products		1,570,000 00
5 flour-mills, value products		960,000 00
5 corn-mills, value products		120,000 00
2 iron-works and machine-shops, value products		192,000 00
4 printing-offices, value products		80,000 00
One paper-mill, one distillery, one brewery, three planing-mills, one tobacco-mill, works, coach, wagon, and other shops, value products		192,000 00
Total value of manufactures		4,062,000 00

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9. Banks and insurance companies:	
First National Bank, capital paid	$200,000 00
Commercial Bank, capital paid	120,000 00
Merchants' Bank, capital paid	400,000 00
Citizens' Bank, capital paid	325,000 00
Planters and Mechanics' Bank, capital paid	150,000 00
People's Savings Bank, capital paid	20,000 00
Firemen and Merchants' Insurance, capital paid	100,000 00
Virginia Life Insurance	200,000 00
Total capital paid in	1,715,000 00
Amount of deposits	1,800,000 00
Total amount	3,895,000 00
10. Miscellaneous:	
The city has invested in river improvements	$200,000 00
Water-works	125,000 00
Buildings and lots	111,000 00
Wharves	16,500 00
Public-school houses	17,000 00
Steam fire-engines and houses	15,500 00
Bonds receivable	250,000 00
Railroad-stocks	300,000 00
	1,035,000 00

RECAPITULATION.

Value of real and personal property	$8,436,000 00
Value of city property	1,035,000 00
Value of agricultural products sold	6,405,000 00
Value of manufactures sold	4,062,000 00
Value of merchandise	8,806,000 00
Value of banks and deposits	3,895,000 00
	32,639,000 00
Taxes, &c.:	
Paid United States	$2,424,019 60
Paid State and municipal	263,700 00
	2,687,719 60

The above statements show more particularly the local interests to be benefited by the improvement of the river to Petersburg. I believe I have only to call your attention to a single fact to show the importance of its speedy completion to the general interests of the country.

Of the 100,792 tons of "through tonnage" of the Southside Railroad, as stated above, 90,617 tons of it passed through Petersburg, and was carried to Norfolk by rail, eighty miles farther, for shipment. This tonnage was composed of cotton, tobacco, and other products of Virginia, Tennessee, Georgia, Alabama, and Mississippi, shipped to Baltimore, Philadelphia, New York, Boston, &c., and return cargoes of merchandise. With the Appomattox River improved to admit to the wharves the class of steamships that carried this tonnage, it can be taken from here at as low rates of freight as from Norfolk, and thus save the shippers the cost of the additional railroad transportation.

What the amount of this saving would be can be seen in what the tonnage paid the railroad company. In their report it is stated that the above tonnage paid them at the rate of 2.94 cents per ton per mile. This, for the whole distance, eighty miles, was at the rate of $2.35\frac{2}{10}$ per ton, which, on the 90,617 tons, amounts to $213,313. This sum, then, represents the annual amount that would be saved to the merchants interested in this trade, even supposing the through tonnage would not increase. But the reports of the railroads show that it increases largely every year. I will say nothing of the saving that will accrue to the northern merchants interested in the trade of North Carolina by making Petersburg the nearest shipping-port of a large portion of it, or what would be saved in reduction of freights by enabling larger vessels to reach our

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wharves. It is obvious it would be considerable, and, added to the others, they all show that the claims of our improvement are justly entitled to the liberal consideration of Congress.

Respectfully, your obedient servant,

H. D. BIRD.

Colonel WILLIAM P. CRAIGHILL,
Corps of Engineers, Chief Engineer of the Improvement of the Virginia Rivers.

Q 14.

IMPROVEMENT OF THE ROANOKE RIVER BELOW WELDON, NORTH CAROLINA.

On the 1st of July, 1871, Mr. J. M. Foote was engaged, under his contract, in removing wrecks near Plymouth. Some delay occurred in getting reasonable offers for the removal of rocks below Weldon and near that town. A contract was finally made with Mr. Foote for that purpose, January 5, 1872. Neither of these operations was completed June 30, 1872, delays having been caused by high water in the river and by the prostration of the contractor by severe malarial illness. They will be completed in 1872.

A boat has been fitted up, at moderate expense for machinery, and provided with a crew, for the removal of snags, overhanging trees, and similar obstructions which have proved dangerous to navigation. The work of this boat and crew has been satisfactory, both as regards progress and useful results.

An appropriation of $10,000 was made June 10, 1872, which will probably be expended in further removal of wrecks, rocks, and snags from the river. A survey of the river from Weldon to its mouth was ordered in the appropriation bill of July 11, 1870, which could not be completed until February, 1871. A preliminary report was submitted February 4, 1871, and printed in House Document No. 60, part 2, Forty-first Congress, third session. The preparation of the maps and reports was delayed by pressure of other duties until December 5, 1871, at which date the report was rendered. It has been printed in Ex. Doc. No. 23, Senate, Forty-second Congress, second session.

The results of this survey were the following:

From the mouth of the river to Indian Highlands Landing and Bar, a distance of about sixty-five miles, there is, at all seasons, a sufficient depth for vessels drawing about 10 feet, which is more than is required for the trade through Albemarle Sound and the canal. A few troublesome wrecks were found in this portion of the river, which are now nearly all removed by contract, the funds therefor being derived from the appropriation of March 3, 1871. Some snags and fallen trees needed taking out, but funds were already available from the same appropriation. Above Indian Highlands Landing to Weldon, about fifty-five miles, the river is so variable in depth as not to afford a continuous low-water navigation of more than 2 or 3 feet. This portion of the stream is therefore considered the only one calling for, at this time, any large expenditure for its improvement. The cost of removing the obstructions and dredging the shoals and bars of this portion of the river, so as to insure a 5-foot navigation at low stage, in a channel-way of not less than 60 feet in width, is estimated at $120,000; but it is believed that the prevalence of frequent high freshets, and their effects on the bed of the river, would endanger the permanence of such improvements, and that

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the circumstances of the case seem to require a resort to the use of training-dikes (of piles wattled with saplings) in order to contract the low-water width of the stream. By this expedient it is highly probable that a low-water depth of 5 feet may be obtained and maintained without resort to dredging.

The following estimates for this method of improvement were submitted:

1. Removing snags, sunken logs, &c	$25,000
2. Removing rocks, &c., near Weldon	10,000
3. Training-dikes, 156,000 linear feet, at $1.50	234,000
	269,000

Deducting amounts available, a balance to be appropriated is left of $249,000.

It has been suggested that the interests involved justify and demand the maintenance of a depth, below Weldon, of not less than 8 feet at all seasons. To do so would probably require an additional expenditure of $250,000; but it is by no means certain that such a depth could be obtained and made permanent.

Appropriated June 10, 1872	$10,000 00
Expended in year ending June 30, 1872	8,782 18
Available for year ending June 30, 1873	20,997 07
Required for year ending June 30, 1874	10,000 00

IMPROVEMENT OF ROANOKE RIVER.

Abstract of bids received December 6, 1871, and opened at 12.10 p. m., in presence of bidders.

Number.	Name.	Address.	PRICE. Cubic yards.	PRICE. For the job.	Commence.	Complete.
1	George Dick	Richmond, Virginia	$30 00		Mar. 1, 1872	Aug. 15, 1872
2	John M. Foote	Plymouth, North Carolina	11 45		July 1, 1872	Jan. 1, 1873
3	John G. Douglass	85 Broad street, New York		$17,450	Jan. 1, 1872	June 1, 1872

CUSTOM-HOUSE, EDENTON, NORTH CAROLINA,
August 12, 1872.

SIR: In reply to your communication of the 2d instant, requesting me to give you certain information in regard to the importance to the local and general interests of the country of the further improvement of the Roanoke River, I have the honor to state that the improvements already made have been beneficial, and when the projected work is completed, the river will be rendered sufficiently navigable to benefit all the commercial interests of the section of country through which it runs.

1. The Roanoke River is situated in the collection-district of Albemarle, North Carolina.

2. The amount of revenue collected from all sources at the port of Edenton, district of Albemarle, North Carolina, during the fiscal year ending June 30, 1872, was $2,989.47.

3. There is no port of entry on the Roanoke River. Edenton is the only port of entry in this collection-district, and is situated on Edenton Bay, near the mouth of Roanoke River.

4. The amount of commerce and navigation, and other interests to be benefited by the further improvement of the Roanoke River, will be, generally speaking, the same as that embraced in my former report on this subject.

Besides the millions of shingles, and large quantities of ash, pine, poplar, and cypress timber carried from the Roanoke and Chowan Rivers and tributaries, and the rivers and creeks tributary to the Albemarle Sound in steam and sail vessels, an immense quantity of heavy timber, constructed into rafts, has been towed through the Albe-

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marle and Chesapeake Canal to Norfolk, Virginia, and up the Chesapeake Bay to northern markets.

There is no material change in the amount of tonnage employed in carrying on the commerce of this customs district. There certainly has not been any decrease either in the navigation or commerce of this section since my last report to you in regard to the improvement of the Roanoke River.

Should there be any other information not herein communicated on any specific subject connected with the improvement of the Roanoke River desired by you, I will be pleased to furnish the same if it is in my power to do so.

I am, sir, very respectfully, your obedient servant,

CHAS. G. MANNING,
Collector of Customs.

Brevet Lieutenant-Colonel WM. P. CRAIGHILL,
Major of Engineers, Baltimore, Maryland.

Q 15.

IMPROVEMENT OF THE MOUTH OF CAPE FEAR RIVER, NORTH CAROLINA.

The operations of the year have been confined chiefly to the continuation of the work for closing the opening between the head of Smith's Island and Zeke's Island, at the New Inlet.

On the 30th of June, 1871, this work extended 757 feet from Smith's Island toward Zeke's. On the 30th of June, 1872, it was 12,915 feet in length. The sand accumulates around it with gratifying rapidity. In addition attention has been given to the maintenance of existing sand-hills and beaches, and the formation of new ones by the use of cheap catch-sand fences, which have succeeded well. Shrubbery and other vegetation suited to the locality have also been planted and cultivated to advantage, with the same object.

A board of engineers met at Wilmington early in 1872, to consider the results of the work already done, and to give opinions as to the proper steps to be taken in the future. A final report has not been made, the board having concluded that no change, at least for the present, was needed in the project of operations in execution, and that it was expedient to defer a judgment until the completion of a survey, then in progress, of the mouths of the river under the supervision of the Superintendent of the United States Coast-Survey.

The data will soon, it is hoped, be provided to enable the board to submit a report. In the mean time, it may be proper to call attention to two important facts.

The stone jettee which protected the lower end of Smith's Island, called Baldhead Point, has been separated from the beach by the action of the winds, waves, and currents, in wearing away the latter. Simultaneously there are indications of a new and straight channel through the Baldhead entrance. This channel seems well defined, increasing in depth, and nearly in the position of the ancient deep channel which existed before the opening of New Inlet. These changes occurring, as they do, simultaneously with the construction of the work between Smith's and Zeke's Islands, seem to confirm the opinion that they may be caused by that work. Undoubtedly much water, formerly passing between Smith's and Zeke's Islands, can no longer take that course, as 2,000 feet of the opening is closed by a solid work. There are good grounds for believing that by steadily carrying forward that work, with the addition of another of smaller extent on the northern side of New Inlet, near Federal Point, that inlet will be entirely closed in a short time by the agency of the winds and waves, and the river restored

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to its condition of a century ago, when New Inlet had no existence, and the old mouth of the river had one of the finest entrances on the South Atlantic coast.

The strong probabilities of attaining such a result, which is of national importance, are enough, it would seem, to justify me in urging a liberal appropriation by Congress for carrying on the work.

Appropriated June 10, 1872	$100,000 00
Expended in year ending June 30, 1872	75,436 49
Available for year ending June 30, 1873	97,049 33
Required for year ending June 30, 1874	150,000 00

Statement of duties collected, value of exports to foreign countries, and navigation, foreign and coastwise, for the year ending June 30, 1872, in the customs district of Wilmington, North Carolina.

Duties collected	$48,348 99
Value of exports	2,278,245 00

	No. of Vessels.	Tonnage.	Men.
Vessels entered from foreign ports	46	11,614	414
Vessels cleared for foreign ports	136	36,725	1,170
Vessels entered coastwise	320	144,885	3,780
Vessels cleared coastwise	174	100,836	2,579

COLLECTOR'S OFFICE, *August* 13, 1872.

Q 16.

EXAMINATION OF WORTON CREEK, MARYLAND.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, April 18, 1872.

GENERAL: On the 15th instant I had the honor to receive your instructions of 13th instant to cause such an examination to be made of Worton Creek as would enable a report to be submitted concerning its condition and proposed improvement. This examination was made on the 16th and 17th instant, by Assistant Engineer William Popp, whose report, dated 18th instant, containing an estimate, and, accompanied by a sketch, is now forwarded.

The letter of Hon. George Vickers, dated April 9, is returned herewith.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

BALTIMORE, MARYLAND, *April* 18, 1872.

MAJOR: I have the honor to submit the following report on the examination of Worton Creek, Maryland, made by me, under your direction, on the 16th and 17th instant.

Worton Creek is situated in Kent County, on the eastern shore of the Chesapeake Bay, due east of Pool's Island light, distant about thirty miles from Baltimore. Some

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fifteen dwellings occupy the banks of the creek. Its importance for commerce consists in the fact that the back country, within a radius of about five miles, ships its produce from Worton Creek. The back country is in a very high state of cultivation, almost every acre of available land being improved. The principal produce consists in peaches, apples, berries, and other fruit, and grain, especially corn. Careful inquiries, which I made about the yearly amount of shipments, furnished the following data, which I consider reliable, as they were given independently by several well-informed parties.

Average amount of shipments per year.

From "Buck-Neck" Wharf:		
Peaches	$125,000	
Potatoes, apples, &c	10,000	
Grain	120,000	
Goods received	60,000	
		$315,000
From "Vanord's" Wharf:		
Peaches, apples, &c	13,000	
Grain	12,000	
		25,000
From "Gale's" Wharf:		
Peaches, berries, &c	40,000	
Grain	60,000	
		100,000
Total		440,000

There is a regular daily line of steamers running from Baltimore to Worton Creek, consisting of two vessels. During the peach season, however, there are three additional steamers running from the place—one to Baltimore, the other two to Philadelphia. The most direct passenger line from Baltimore to Chestertown, the county seat, passes through Worton Creek.

The creek has also some importance as a harbor of refuge, because there are no harbors within a distance of twelve miles. At the time of my arrival at the place, there was a strong northwest wind blowing, and I counted eleven vessels which had taken refuge in the harbor. Six of them could not enter the inner harbor on account of its shoalness, and were, therefore, partly exposed to the action of the wind and waves.

It will be seen, from the accompanying sketch, that the creek consists of two distinct ports, viz, the outer harbor, (which opens toward the northwest, and is, therefore, exposed to gales blowing from that direction,) and the inner harbor. This outer harbor might be rendered perfectly safe by running a breakwater from the northern point, at its entrance, in a southeasterly direction, a distance of about 1,500 feet. This, however, is not contemplated at this time, as it is believed that the inner harbor would afford room enough for the present demands of commerce.

The inner harbor extends from point marked A to head of creek; its depth decreases from 8 feet at A to 4 feet 6 inches at Buck-Neck Wharf. It is desired to give a channel 100 feet wide at bottom, and 8 feet deep, at mean low water, up to Buck-Neck Wharf.

The creek is filled to a depth of over 15 feet with a very soft, semi-fluid mud, the removal of which by dredging would offer no difficulty. Consisting, as it does, chiefly of decomposed vegetable matter, it would form excellent manure, and the farmers in the vicinity would be glad to remove it to their fields if deposited on their wharves.

My estimate for the desired improvement is based upon 500 soundings, and several tests of the bottom, and amounts to $12,000.

Very respectfully, your most obedient servant,

WILLIAM POPP.

Major W. P. CRAIGHILL,
Corps of Engineers, U. S. A., Baltimore, Maryland.

Q 17.

EXAMINATION OF NORTHEAST RIVER, MARYLAND.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, April 8, 1872.

GENERAL: I have the honor to return herewith the papers concerning the desired improvement of Northeast River, in Cecil County, Maryland, which were referred to me on the 14th of March.

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Adverse circumstances, beyond my control, have prevented earlier attention to this matter.

The locality has been visited by Assistant Engineer N. H. Hutton, a copy of whose report of the 6th of this month is inclosed herewith, containing all the information attainable at this time, without a formal survey, for which there are no available funds.

The information now furnished is believed to be sufficient for present purposes.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, April 6, 1872.

COLONEL: I have the honor to submit the following report of a reconnoissance of the Northeast River, Maryland, at and near the town of the same name, made by me on the 5th instant, under your instructions.

The town of Northeast is situated on the river of that name, about five miles above its debouche into Chesapeake Bay, at its head. It is also on the line of the Philadelphia, Wilmington, and Baltimore Railroad, about forty-six miles from Baltimore. The two streams, Great and Little Northeast, unite here to form the Northeast River. The town now contains an extensive sheet and bar iron manufactory, a fire-brick and tile factory, grist and saw mills, and the river for three miles above town affords water-power sufficient for the establishment and operation of manufactures, &c., of considerable extent and value, the total fall in that distance being a little over 350 feet.

The Northeast River, at the town, has a width of about 150 feet, and a depth of about 6 feet; it rapidly expands in width, until at its mouth it measures one and three-fourths miles across, with a depth of from 8 to 10 feet at low water.

Immediately below the town an extensive shoal is formed, having, at low water, on it a depth of less than 2 feet, which effectually cuts off access to the town by water.

From all the information I could gather, it is the desire of the people of this section to obtain a channel 6 feet deep, at low water, through this shoal, in order that the mills already established, and those in contemplation, may receive their crude supplies of coal, iron, lumber, and cotton, by water.

To effect this object will require the excavation of a channel about 1,300 yards long, and assuming a width of 25 yards as sufficient, this would cost between $9,000 and $10,000.

The bottom is generally quite soft, and the excavation would be easy of execution.

Accompanying this is a tracing, from Coast-Survey chart, showing general location of Northeast Town and River.

Respectfully, your obedient servant,

N. H. HUTTON, *Assistant.*

Colonel WM. P. CRAIGHILL,
Corps of Engineers.

Q 18.

SHIP-CANAL, CHESAPEAKE AND DELAWARE BAYS.

UNITED STATES ENGINEER OFFICE,
No. 399 DRUID HILL AVENUE,
Baltimore, Maryland, March 25, 1872.

GENERAL: I have had the honor to receive, with directions to report thereon, a copy of a resolution of the House of Representatives of 11th of March, 1872, in the following words, viz:

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FORTY-SECOND CONGRESS, SECOND SESSION.
Congress of the United States, in the House of Representatives, March 11, 1872.

On motion of Mr. Swann,

Resolved, That the Secretary of War be requested to communicate to Congress any information he may have upon the subject of the construction of a ship-canal from the waters of the Chesapeake to the waters of the Delaware Bay, and to state how much time would be saved by such improvement in the passage of ships from Baltimore to and from Liverpool and other foreign ports, and whether the building of such canal would not materially advance the interests of commerce.

Attest:

EDW'D McPHERSON, *Clerk.*

Until a careful survey and comparison of lines for the proposed canal have determined its location, and consequently its length, it will be impossible to say with precision "how much time would be saved by such an improvement in the passage of ships from Baltimore to and from Liverpool and other foreign ports."

This question, and the other question of the resolution of the House of Representatives, viz, "whether the building of such canal would not materially advance the interests of commerce," are treated at some length in the attached copies of communications, to which attention is invited. One of these was made to yourself on the 29th of February by the Hon. James T. Earle, of the joint committee of the legislature of Maryland, on behalf of that State, and of Governor Ponder, of the State of Delaware.

The other is a letter dated March 22, 1872, from Mr. A. Harris, who is the agent in this city of several lines of steamships.

The following resolution was adopted by the National Commercial Convention, which assembled in this city last autumn:

Resolved, That Congress be memorialized to direct a survey to be made between the Chesapeake and Delaware Bays, for the proposed improvement; and, if found to be practicable, desirable, and valuable to the great interests of the country, that the said ship-canal shall be constructed.

It is apparent from an inspection of a good general map that a canal connecting the two bays, as proposed, would materially shorten the distance from Baltimore to and from Liverpool and many other foreign ports, as well as those on our coast north of Baltimore.

The papers herewith estimate this distance as one hundred and eighty-two miles each way, or three hundred and sixty-four miles each trip. An examination of the maps in this office leads me to conclude that the estimate is not far from accuracy. As before stated, the exact saving of distance can be only settled after a survey and location of the line of the canal.

The commercial advantages of the proposed canal seem sufficiently set forth for present purposes in the communications hereto attached. No reliable estimate of the cost of constructing the canal can be given without careful preliminary surveys. The length of line will probably not be less than thirty nor exceed fifty-five miles, depending on the location. The character of the country through which the canal would pass, by any proper route that might be selected having the proposed object in view, is favorable for such a work.

Should Congress determine to authorize the surveys necessary for deciding as to the location and cost of the work, it is recommended that an appropriation of not less than $20,000 be made for that object.

It may not be superfluous to add that a canal is already in existence, connecting the head of Chesapeake Bay, via Elk and Back Rivers, with the Delaware River at Delaware City; but this has neither depth nor width enough for the accommodation of steamers or sailing-vessels de-

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signed to cross the Atlantic. Whether, considering the objects to be accomplished, the location of this canal is admissible, even if deepened and widened, is a question for determination after the completion of a survey and estimates.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

Remarks submitted to General Humphreys, of the War Department, on the 29th of February, by the Hon. James T. Earle, of the joint committee of the legislature of Maryland, on behalf of the State, and of Governor Ponder of Delaware, on the subject of a ship-canal to connect the waters of the Chesapeake and Delaware Bays, with a view to procure a detail from the Topographical Engineer Corps to make surveys, to determine the feasibility of such a work, its most advantageous route, and an approximate estimate of its cost, and report the same to the said Department.

GENERAL: The joint committee of the legislature of Maryland, on behalf of their State, and I am sure I may say of Delaware, so well represented here by her governor in the recess of her legislature, desire, through their chairman, to express their thanks for the prompt audience you have given them on the subject of their mission. We have been instructed to seek this hearing, general, that we might ask of your Department a detail from the Corps of Topographical Engineers, to make surveys for a ship-canal across the peninsula of Maryland and Delaware, to connect the waters of the Chesapeake and Delaware Bays. There is nothing new in the suggestion of such a work. It has been often made, and for many years the intelligent portion of the populations of both States have looked to its undertaking and accomplishment, under the developing influence of the necessities of trade, as a fact which must sooner or later occur. These necessities, under the rapid strides of progress, refuse to be longer denied their just demands, and it is in obedience to such high behests that we are before you. The demands of trade have ever spoken in clear and unmistakable language, and refused denial of the advantages claimed as proper and necessary for its accommodation. In these demands the young giant of the West, now attained to the stature of manhood, and rapidly progressing to the maturity of riper age, joins with our States of the Atlantic board in requiring a way of easy and ready access to the ocean, that, in common with us, he may be admitted to equal participation in the commerce of the world. Shall requests so reasonable, though urgently pressed, as they should be, be denied? Our State, as may be gathered from her legislative history for a period of nearly two-score years and ten, has looked with steady and undoubting anticipations to the accomplishment of her works of internal improvement for the consummation of this great purpose. At last we are able by our system of railroads to throw wide open our doors, with the latch always upon the outside, and bid the giant of the West welcome to our domiciles; most cheerfully we accord him a pathway across our territory to the sea-board.

We have not made this invitation an empty thing that cannot be accepted, but have smoothed the path and provided the way by which we can have the enjoyment of his good company to breakfast, and, if he will not tarry longer with us, by which he can return to his own household to tea. This is no sketch of fancy, general, but is fast becoming an every-day experience. The great West lies upon the outskirts of Maryland and Delaware, and Maryland, having with that great territory a common interest, is fast beginning to realize the agreeable and profitable fact that she is the nucleus around which center, in the bond of a common interest, the South and the West, the Southwest and the Northwest; and, from her geographical position, holds relations with the North and the East which must be promotive alike of friendly connections and extensive and advantageous trade. Shall we let the little narrow strip of land between these two great bays be longer a barrier in the way of easy access to the ocean, to the immense trade of a territory constituting in its vastness a great empire, and which finds its most natural outlet to the markets of the world through the waters of the Chesapeake? This trade, already swollen to large proportions, but as yet in its infancy, must pass through Baltimore, and it thus becomes a matter of national importance, in which more than half the States of this Union are interested, that Baltimore should be brought near to the ocean by the shortest possible line of connection. Baltimore, within comparatively a few years, has grown to be a great city, claiming to rank among the leading cities on this continent in enterprise, in

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wealth, in commerce, in manufactures, in arts, and in all the elements which enter into and constitute a great emporium. Near the head of a great estuary, the boldest indentation of water on the Atlantic board, her locality is fixed and stable, and perhaps more advantageously, with reference to the great trade-centers of the country, than any other that could have been selected. The only disadvantages under which she labors from her position, arise from insufficient depth of water from her docks to the mouth of the Patapsco, and her remote distance from the ocean; fortunately these can be overcome by proper application of means and the engineering skill of the age; and in the already increased depth of water which has been secured, and the facility with which the Patapsco is now navigated by the Berlin steamers of twenty five hundred tons burden, we have the evidence of what can be accomplished, and of how entirely these obstacles in the way of trade are under our control.

The General Government, impressed with the disadvantages of her position in these respects as drawbacks to trade, and an interference with the general commerce of the country, has recognized the removal of them as of national importance; and Congress has from time to time made appropriations, with the view of accomplishing these results. That they will be removed in a few years, we have the best guarantee in the imperative necessities of trade, and in the demand which the great West will join Baltimore in making upon the authorities of the General Government for the accomplishment of this end. We have only, general, to cast the eye over the map which I hold in my hand, and glance at the routes of our great work of internal improvements, the Baltimore and Ohio Railroad, and its branches and communications, to feel ourselves sustained in these statements, and to be made sensible that they are not mere conjectures, but realities arising from existing facts.

I desire to call your attention to the distance between the city of Baltimore and the great centers of trade, to which I would attract your observation, as compared with the relative distances of the same points from the city of New York. Chicago, Illinois, is distant from Baltimore, via the Baltimore and Ohio Railroad, 795 miles; from New York, via New York Central Railroad, 980 miles; via Erie Railway, 961 miles; and via Pennsylvania Railroad, 899 miles; nearer to Baltimore than to New York by average distance of 152 miles. Saint Louis, Missouri, is distant from Baltimore, via Baltimore and Ohio Railroad, 929 miles; from New York, via New York Central Railroad, 1,167 miles; via Erie Railway, 1,201 miles; and via the Pennsylvania Railroad, 1,050 miles: nearer to Baltimore than to New York by average distance of 210 miles. Louisville, Kentucky, is distant from Baltimore, via Baltimore and Ohio Railroad, 696 miles; from New York, via New York Central Railroad, 989 miles; via Erie Railway, 987 miles: and via Pennsylvania Railroad, 851 miles; nearer to Baltimore than to New York by average distance of 246 miles. Cincinnati, Ohio, distant from Baltimore, via Baltimore and Ohio Railroad, 589 miles; from New York, via New York Central Railroad, 882 miles; via Erie Railway, 861 miles; via Pennsylvania Railroad, 744 miles; nearer Baltimore than to New York by average distance of 240 miles. Pittsburgh, Pennsylvania, is distant from Baltimore, via Baltimore and Ohio Railroad, 327 miles; from New York, via the Pennsylvania Railroad, 431 miles; nearer to Baltimore than to New York by 104 miles. The proximity of Baltimore to the principal centers of trade, secured by the advantages of locality, and the sagacity and able and far-reaching management of our great work of internal improvement, the Baltimore and Ohio Railroad, give to these important points, in the economies of transportation and trade, advantages greater in these respects than they can enjoy by shipment to other points. Besides, we have other important works, the Northern Central Railroad and the great Pennsylvania Central, especially its branches and its connections recently formed to the south of us, which bring a large amount of produce and trade to our city. Properly estimating the advantages of low port charges and economical transportation, the New York importer, when he proposes to supply with coffee the vast region over which these works extend, consults the economies of trade, and orders his ship to Baltimore, and not to New York. These statements and these figures, general, bespeak, more eloquently than any language I could hope to employ, the national character of the work for which it has been made our agreeable duty to ask your consideration.

And having, I trust, sufficiently demonstrated this, we desire next to ask your attention to the difference in distance from Baltimore to the European ports, and to New York, Boston, and other northern ports, by the present route and by that which we shall hope to see before many years accomplished, in the construction of the proposed ship-canal. In referring to these distances, we desire to be regarded as speaking approximately only, as we have not the data to enable us to do so with accuracy. The distance from Baltimore, by our bay, to the capes, is from 190 to 200 miles. Having passed the capes, a ship bound either for a European port or for New York or Boston, has to run on a line somewhat parallel to our coast for the distance of about 100 miles, before she lays her course for either of the ports indicated, thus making the distance of something over three hundred miles before she reaches the point of the ocean from which she may be regarded as fairly on her way to Europe or the ports to the north of us. By the proposed canal, which should be cut and constructed, without reference to

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cost, by the shortest line between Baltimore and the ocean, I do not think the distance, as near as can be arrived at by the inaccurate means of measurement at my disposal, will exceed one hundred and eighteen miles, thus making the saving in distance 182 miles, which figures correspond with the views of a distinguished gentleman, who, as expressed to me, has given the subject a great deal of attention. (I refer to Mr. Garrett.) You ask me, general, as to the locality of the route. Pardon me; I, of course, have my views in regard to it, but wish the engineers to be entirely free and untrammeled, and if I had control of the survey, would give them but the one direction, which I have suggested. This saving in distance is not only important as saving in time and controlling the delivery of freight at its point of destination some fifteen hours in advance of the time by the present route, but, in economy, is of not less importance to the owners of large and expensive steamships.

For illustration, we will take a large-class ship of the Allan line, whose consumption of fuel is from one hundred to one hundred and fifty tons every twenty-four hours, and whose expenses, in round numbers, may be set down at a thousand dollars a day, wear and tear of the ship and consequent impairment of principal considered.

The saving in distance of one hundred and eighty-two miles, equivalent in saving in time to about fifteen hours, would be an economy of $625, either to the ports to the north or to European ports, which, allowing twelve trips to be made each way, or twenty-four crossings of the ocean in a year, would amount to $15,200, equivalent to more than a three per cent. interest on a capital of half a million of dollars invested in the ship.

With your permission, general, in connection with the ship-canal, we will invite your attention to some few reflections on the use and consumption of coal used in the propelling of steamers, as entering largely into the economies of transportation and commerce.

The great ocean-steamship companies of New York are supplied with coal from the Cumberland mines, brought by the Baltimore and Ohio Railroad to Baltimore, and shipped thence to New York, at a cost for freight of $2.50 per ton. The steamships, therefore, from Baltimore to European ports, using eight hundred tons, save, as compared with those of the same class running from New York, $2,000 on each voyage. To the advantage of the economies thus secured, we must not forget to add that which is perhaps the most important of them all, the economy and advantage in the use of the Cumberland coal for steam-generating purposes over all other coals yet brought into general use; and for the tests on this subject, I desire to refer to a statement in the American, of the 5th of May, 1871, extracted from the Springfield, Massachusetts, Republican, of the 28th of April of the same year, in which, after prefacing remarks on the subject of coals, it is stated that experiments have been made in the national armory at Springfield, with a view of testing and arriving at their comparative values, and that the following facts were established as the results of these experiments, which are stated to have been made by Colonel Benton.

He had each of three different kinds of coal used for six consecutive days, in making steam for the engine of that establishment: first, the Lackawanna, or the hardest of anthracite coals; second, the Pittston, or softer anthracite; and third, the Cumberland, or bituminous coal of Maryland. The results were as follows: Of the Lackawanna coal, the number of pounds used, per horse-power per hour, was 4.01 pounds; of the Pittston, 4.02; of the Cumberland, 3.03. The coal cost at the armory, Lackawanna, $8.50 per ton of 2,240 pounds, or $0.00379 per pound; the Pittston, $8.75 per ton, or $0.00396 per pound; the Cumberland, $9.10 per ton, or $0.00406 per pound; which would make the cost of the coals, per horse-power per hour, as follows: Lackawanna, $0.151979; Pittston, $0.159192; Cumberland, $0.123028.

Of course these figures make clear the fact that, even at a higher price per ton, the bituminous or soft coal is the more economical, making more heat and creating more power per pound and per cent. of cost than the harder coals. Some statistics from another source indicate that, while one pound of Cumberland coal evaporates ten pounds of water into steam, a pound of the Newcastle (English) coal evaporates but 7.90 pounds of water, the American anthracite 7 pounds, English Staffordshire 6.40 pounds, and dry pine wood 3.10. These experiments show too clearly to require comment the superiority of the Cumberland coal over those with which it was tested, (and they have been regarded as among the best,) and the great economy in its use. This economy is greatly enhanced when this coal is delivered at the docks in Baltimore at very much less cost than any other, and without the added cost of transportation to Springfield and other points. Where Cumberland coal is used in propelling machinery, it has been found that the boiler will last at least a third longer than where anthracite coal is used. These statements, which have been made with reference to the mercantile marine of our country, apply with equal or greater force to the large ships of our Navy. Then, general, let our Government pursue the wise policy of deepening the channel of the Patapsco to its mouth, and bringing Baltimore fifteen hours nearer in time to the ports of Europe and to those of the northern section of our own country by the proposed ship-canal, and in a few years the impost revenue received by the

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Federal Government at this port will be increased from nine to twenty millions of dollars a year, and the saving to the Government in the economies of time and wear and tear of vessels and machinery will be greatly more than sufficient to construct this important national link.

Thanking you again, general, for your very courteous attention to our statement, and to the detail of our remarks, which have been unavoidably somewhat tedious, and for the interest you have been pleased to express in the object of our mission, we will leave the subject in your hands, in the full confidence that it will receive the consideration to which its merits and importance as a great national question justly entitle it.

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95 McCULLOUGH STREET, BALTIMORE,
March 22, 1872.

DEAR SIR: Responding to your esteemed favor of 18th instant, I beg to hand you herewith a pamphlet copy of proceedings of the National Commercial Convention, held in this city in September, 1871, and refer you to the preamble and resolutions relative to the proposed Chesapeake and Delaware ship-canal, (page 171,) and to the remarks made in connection with that subject by the Hon. Reverdy Johnson.

I can hardly hope to be able to add to the information in regard to the proposed improvement which is contained in the pamphlet referred to. The preamble sets forth the fact that a saving of 183 miles would be effected in the distance between Baltimore and the principal ports of Europe, and it should be kept in mind that the route for sea-going vessels between Baltimore and the ports of New England would be shortened to the same extent. To accomplish this result, a canal of only 32 miles in length is stated to be required. The preamble characterizes the proposed work as being of national importance, and especially desirable to the West, South, Southwest, and Northwest. That Baltimore is the sea-port nearest to those vast regions, and consequently the proper commercial outlet for their products, may be illustrated by the following statements of comparative distances, by rail, to Baltimore and to New York:

From Chicago, Illinois.

	Miles.
To Baltimore via Baltimore and Ohio Railroad	73[illegible]
To New York via New York Central Railroad	[illegible]
To New York via Erie Railway	9[illegible]
To New York via Pennsylvania Central Railroad	[illegible]
Less to Baltimore than the average distance to New York	15[illegible]

From Saint Louis, Missouri.

	Miles.
To Baltimore via Baltimore and Ohio Railroad	92[illegible]
To New York via New York Central Railroad	1,16[illegible]
To New York via Erie Railway	1,20[illegible]
To New York via Pennsylvania Railroad	1,16[illegible]
Less to Baltimore than the average distance to New York	21[illegible]

From Louisville, Kentucky.

	Miles.
To Baltimore via Baltimore and Ohio Railroad	69[illegible]
To New York via New York Central Railroad	9[illegible]
To New York via Erie Railway	9[illegible]
To New York via Pennsylvania Central Railroad	85[illegible]
Less to Baltimore than the average distance to New York	24[illegible]

From Cincinnati, Ohio.

	Miles.
To Baltimore via Baltimore and Ohio Railroad	58[illegible]
To New York via New York Central Railroad	[illegible]
To New York via Erie Railway	[illegible]
To New York via Pennsylvania Central Railroad	74[illegible]
Less to Baltimore than average distance to New York	24[illegible]

In regard to the saving of time in the passage of ships between Baltimore and Liverpool which would be effected by the proposed improvement, the detentions to which even steamships are sometimes subjected in the Chesapeake Bay from fogs and other causes, render this difficult to estimate. It would probably be safe to state, however, that the voyages of steamers would be shortened from twenty-four to forty-eight hours, and the voyages of sailing-vessels a much longer period.

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There can be no question as to whether the "construction of the proposed canal would materially advance the interests of commerce." The saving which it would accomplish for the owners of the vast fleets which, for all time, would continue to use it, would alone form no inconsiderable item of economy; but when the importance of the saving to result to the owners of the cargoes of these fleets, and to the varied interests throughout the nation which would be connected with a commerce of such magnitude, are duly considered, the difficulties and cost of construction of such a work dwindle to insignificance.

The interesting statistics, relative to the commerce of this port, which were recently furnished your office, from the office of the collector of customs, and referred to in your report concerning the improvement of the channel which bears your name, will aid in demonstrating the great utility of the improvement under consideration.

Regretting that the brief time allowed has prevented the collection of additional statistics, and hoping you will again call on me, if I can at any time assist in promoting the important object in view,

I remain, dear sir, very respectfully, yours,

A. HARRIS.

Colonel WILLIAM P. CRAIGHILL,
United States Engineer Office, Baltimore, Maryland.

Q 19.

AQUIA CREEK, ACCOTINK, NEABSCO, QUANTICO, AND CHOPPAWAMASIC BAYS.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, January 22, 1872.

GENERAL: A survey of each of the following localities on the Potomac River was ordered in the appropriation bill for the improvement and survey of rivers and harbors, approved March 3, 1871, viz, Aquia Creek, Accotink, Neabsco, Quantico, and Choppawamasic Bays.

The field-work was taken in hand as soon as other requirements permitted, and was executed in the months of June and July, 1871, under the immediate supervision of Captain C. B. Phillips, Corps of Engineers, zealously and intelligently assisted by Mr. J. E. Weyss and Mr. Gilbert Thompson. Other duties, which could not be postponed, delayed the completion of the office-work until this time. The reports of Captain Phillips, dated January 20, 1872, are submitted herewith. A separate map is made for each place, and is forwarded to-day. The reports for Quantico and Choppawamasic are in one communication. Those for the remaining three localities are separate.

Accotink and Pohick Bays unite to form Gunsen's Cove, of which the mouth is distant about eighteen miles from Washington. The mouth of Neabsco is about twenty-eight miles from Washington, and Quantico and Choppawamasic empty into the Potomac River about forty miles from the same city. The mouth of Aquia Creek is about fifty miles from Washington.

Captain Phillips submits plans of improvement for each of the places under consideration, except Quantico, where nothing seems required at present. The estimates are as follows:

For Accotink Bay, channel 5 feet deep at low water	$14,081 76
For Neabsco Bay, channel 6 feet deep at low water	10,215 26
For Choppawamasic Bay, channel 10 feet deep at low water	6,945 40
For Choppawamasic Bay, channel 12 feet deep at low water	9,522 92
For Aquia Creek	13,505 14

I think it would be safe to increase the estimated cost of improve-

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ment about 33 per cent. for Accotink, Neabsco, and Aquia. The estimates would then be as follows in round numbers:

For Accotink	$19,000
For Neabsco	13,500
For Choppawamasic, $7,000, or for deeper channel	10,000
For Aquia Creek	18,000

It will be observed that the above estimates are for certain depths at low water. As the tide rises about 2½ feet, this additional depth can be had at high water each day.

If Congress should decide to make appropriations for these localities, the plans of improvement suggested by Captain Phillips seem judicious. If the work is entered upon at either place, it would be economical to complete it in a single season, and with this object the whole of the estimate for it should be appropriated at one time.

In connection with the reports and special maps now submitted, reference is requested to a good general map of the Potomac River and its adjacent country. It would thence appear that the benefit of the improvements indicated would be not only not confined to the localities themselves, but would be directly participated in by Washington and Alexandria, as well as other cities and towns situated on the same great thoroughfares of trade, the Potomac River and Chesapeake Bay.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

UNITED STATES ENGINEER OFFICE, 2425 K STREET.
Washington, D. C., January 28, 1872.

MAJOR: I have the honor to state that, in accordance with instructions received from you, I have completed a survey of Aquia Creek, Virginia, and I submit herewith my report, accompanied by a tracing from the original chart of the survey. I was assisted in the survey by Messrs. J. E. Weyss and G. Thompson, the party consisting otherwise of seven laborers and boatmen.

Both shore-lines were run; all unoccupied stations (used for the purpose of taking soundings) were carefully located by means of angles taken from the shore.

A tide-gauge was kept during the time of the survey, and mean low water was established as accurately as possible. All soundings are reduced to this reference.

The survey was commenced on the 24th of June and finished on the 7th of July last, eleven days being occupied in the survey.

Total length of shore-line run, eighteen and one-fifth miles; number of occupied stations, 621; number of angles read, 1,636; number of soundings, 1,646.

Aquia Creek is an estuary of the Potomac River, and empties into the latter at a point about fifty miles below Washington City. It is located in Stafford County, Virginia, and in the collection district of Alexandria.

The upper portion of the stream (or the creek proper) has a well-defined channel and winds its way through extensive marshes, which are each year becoming more firm. Where this formation exists the water is confined to a narrow space, and a good depth is maintained.

At a point about five miles from the mouth of the creek, (called "the narrows,") the stream suddenly expands and forms what might be properly called a bay. Here the water becomes shallow, distributing itself pretty uniformly over the whole expanse, and no distinct channel is to be found. Thus, in passing down by the "narrows," where we have 12 to 15 feet of water, we suddenly come to a depth of only 2 feet at low water. From this point the bottom forms a pretty regularly inclined plane, the water gradually deepening as we approach the mouth. The bottom is of soft mud, into which a pole can easily be pushed to a depth of 7 or 8 feet.

Aquia Creek is quite an important tributary of the Potomac. Its course is through

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a tract of country abounding in resources. The soil is fertile; timber is abundant. Vast deposits of the well-known Aquia Creek sandstone are to be found in the bluffs along the banks. Much of this stone was in former years used by the Government at some of its important structures. The business of quarrying this stone has latterly been revived to a considerable extent; but the difficulty of navigation is a serious drawback to the development of this branch of industry. Owing to the shallow water, the flat-boats in which this stone is transported can be loaded to not more than half their capacity. Add to this the loss of time in waiting for high water, and it would be found that the cost of transportation is fully double what it would be with a good channel.

A copy of an extract from a letter from J. H. Harper, esq., the manager of the Mount Pleasant Freestone Company, (and which accompanies this report,) will show his views on the matter. He also refers to other matters concerning the creek. His letter is entitled to consideration.

In the vicinity of Aquia Creek, and depending on it for the transportation of their product, are to be found six steam saw-mills and ten grist-mills. About twenty farms (of 200 acres each on an average) also depend on this creek for their transportation, I am told. Large amounts of timber, wood, staves, &c., are shipped from here.

I have been unable to get any reliable estimate as to even the approximate amount of the above-mentioned products shipped annually.

Several small fisheries are to be found at the lower part of the creek. The usual annual catch of herrings amounts to be about 120,000.

At the mouth of Aquia Creek the Richmond, Fredericksburgh and Potomac Railroad finds its present terminus, the route on from thence to Washington being by boat. The new extension of this railroad (now in course of construction) crosses Aquia at a point about four miles from the mouth, as will be seen by the accompanying tracing, and finds its projected terminus at the mouth of Quantico, as mentioned in the report on the survey of that bay.

To improve the navigation of Aquia Creek, I would recommend the cutting of a channel 40 feet in width at the bottom, and 6 feet in depth at mean low water, from the "narrows" to that point below the new railroad-bridge where 6 feet of water is to be found.

The course which I would propose for such a cut is to be found in blue lines upon the accompanying tracing.

The draw in the railroad-bridge was not properly located by the company, and a slight deviation from the proper course for such a channel is necessitated.

The great expanse of the bay and the character of the bottom would seem to indicate that no permanent improvement would be likely to result from the mere dredging of a channel-way.

A very simple and inexpensive expedient has been adopted at one or two points on Accotink Creek, (referred to in the report on survey of same,) to confine the stream within narrow limits and prevent the channel from filling up after having been dredged.

The plan consists of driving poles or posts some 5 or 6 inches in diameter, and some 6 or 8 feet apart, on either side of the channel to be dredged, and then working in a wattling of sapplings, forming a sort of hurdle, behind which the excavated mud is deposited.

The main cost of such an affair is the labor only; and it is believed that such an arrangement would stand until the bank which would be formed behind it would become covered with the rank vegetation with which the locality abounds. The planting of slips of willow would add much to the permanence of these banks.

It is estimated that this wattling could be constructed at an expense of about $2 per linear rod. I would therefore recommend that, in case an improvement of Aquia Creek is attempted, this plan of wattling be adopted, at least as far down as the new railroad-bridge. Below that point, it would probably interfere with the fisheries. Besides, the proposed cutting below the bridge is very light.

A berme of 5 or 6 feet should be left between the cut and the wattling, to allow for the slopes which the sides of the cut would assume.

To excavate such a channel as proposed would require the removal of 51,657 cubic yards of material; 972 rods of wattling would be required to carry out the above-proposed plan.

The following estimates are submitted as the probable cost of carrying out the proposed improvements:

Excavating 51,667 cubic yards of material, at 20 cents	$10,333 40
Wattling, 972 rods, at $2	1,944 00
Contingencies, superintendence, &c., 10 per cent	1,227 74
Total	13,505 14

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In conclusion, I beg to acknowledge my indebtedness to Messrs. Weyss and Thompson for their valuable services in assisting in the prosecution of the survey, and also during the performance of the office-work which has followed.

I am, major, very respectfully, your obedient servant,

CHAS. B. PHILLIPS,
Corps of Engineers, U. S. A.

Major W. P. CRAIGHILL,
Corps of Engineers, U. S. A., Baltimore, Maryland.

ALEXANDRIA, VIRGINIA, *January* 19, 1872.

MY DEAR SIR: Concerning Aquia Creek, I would say that it is one of the largest and most important creeks that empty into the Potomac River, running inland for upward of twelve miles, and is the outlet for an immense quantity of the finest ship-timber, lumber, wood, staves, freestone, corn, wheat, rye, oats, &c.

* * * * * * * * *

On and near Aquia Creek there are six or eight settlements, six steam saw-mills, ten grist-mills, and immense tracts of fine timber-land. The great drawback that this section is laboring under at this time is the want of a sufficient depth of water in the creek.

* * * * * * * * * * * *

On this creek there are most valuable freestone quarries in this country, where thousands of men can find employment in working them, and at this time the Mount Pleasant Freestone Company are at work with a large force in getting out stone for the use of the Long Bridge, and other works of importance, and by clearing this creek this material can be put into the market at one-fourth of its present cost, and it would come into general use as a cheap, permanent, and fire-proof material for building purposes. The Government itself would be the largest consumer.

There are at the present time some fifteen or twenty sail of vessels and four steamers employed in this creek, and if the latter were cleared the trade would be largely increased by admitting a larger class of vessels.

The Government having entire control over the waters, and receiving all the revenue, it would be to her interest to remove these obstructions, as it would not only increase the size and number of vessels, but increase the revenue, and open up trade to hundreds of thousands of dollars a year, all of which would find its way to Washington City, and be principally consumed by the Government.

* * * * * * * * * * *

With much respect,

J. H. HARPER.

Captain C. B. PHILLIPS,
United States Engineer Corps.

UNITED STATES ENGINEER OFFICE, 2425 K STREET.
Washington, D. C., January 20, 1871.

MAJOR: I have the honor to state that, in compliance with orders received from you, I have completed a survey of Accotink Bay, Virginia, and I submit herewith my report, accompanied by a tracing from the original chart of the survey.

I was assisted in the survey by Messrs. J. E. Weyss and G. Thompson, the party consisting otherwise of seven laborers and boatmen.

The plan of survey adopted was in every respect similar to that described in the report on Aquia Creek.

The survey was commenced on the 19th and finished on the 23d of June last, five days being occupied on it. Total length of shore-line run, six and four-fifths miles; number of occupied stations, 174; number of angles read, 673; number of soundings, 371.

Accotink Bay unites with Pohick Bay in forming what is known as Gunsen's Cove, the latter being an estuary of the Potomac River, and emptying into the same at a point about eighteen miles below Washington City.

The village of Accotink is situated on Accotink Creek, in Fairfax County, Virginia, (collection-district of Alexandria,) and is located about five miles from the Potomac River. The village consists of about twenty dwellings, one large saw, grist, and bolting mill, three blacksmith's shops, and two stores.

About fifty families reside within a radius of six miles, farming and lumbering being the principal occupation of the residents. The people are mostly of a particularly thriving class, being principally Quakers, who formed a settlement here some fifteen years ago.

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Troth's mills (referred to above) turn out about one million feet of sawed lumber per year, and grind about one thousand bushels of corn per month, and also bolt about the same quantity of wheat.

About 30,000 cords of wood are shipped annually from Accotink; also, a considerable quantity of ship-timber.

The shipping of Accotink consists of one stern-wheel steamer and three or four light-draught schooners, engaged principally in the grain and lumber business. These craft can pass up and down the creek (when loaded) only at high water, and even then with difficulty.

The farmers in the vicinity are much interested in the use of various fertilizers, and complain of the difficulty and expense of obtaining the same, the press of the lumber business requiring the craft to oftentimes return light on account of the saving in time.

A channel 40 feet in width at bottom, and 5 feet in depth at mean low water, from the village to the mouth of the bay, would prove a great benefit to the village of Accotink and the surrounding country, and would also meet their modest expectations.

A considerable amount has been expended upon the channel by enterprising persons to improve the particularly bad points, but, their appliances being rude, little lasting benefit has resulted therefrom.

The great expanse of the bay, and the character of the bottom, (being of soft mud,) would seem to indicate that no permanent improvement would be likely to result from the mere dredging of a channel-way. This applies to the lower part of the bay more particularly. At the upper part (or in the creek proper) the mere dredging of a channel would probably prove of lasting benefit.

For the protection of the lower part of the proposed cut a wattling or wicker-work is therefore recommended, as proposed at Aquia Creek.

It was at this point my attention was attracted to the above simple expedient for retaining the excavated material. It has met with tolerable success here, but has not been applied to an extent sufficient to prove of much use.

To excavate a channel from the mouth of the bay to the village 40 feet in width at bottom and 5 feet in depth at mean low water would require the removal of 57,948 cubic yards of material.

The course which I would recommend for the channel proposed above is indicated in blue lines on the accompanying tracing.

The following estimates are submitted for the cost of the improvements suggested above:

Excavating 57,948 cubic yards of material, at 20 cents	$11,589 60
Wattling, 606 rods, at $2	1,212 00
Add for contingencies, superintendence, &c., 10 per cent	1,280 16
Total	14,081 76

In conclusion, I beg to acknowledge my appreciation of the services of Messrs. Weyss and Thompson during the survey, as well as during the time occupied by the office-work which has followed.

I am, major, very respectfully, your obedient servant.

CHAS. B. PHILLIPS,
Captain of Engineers, U. S. A.

Major W. P. CRAIGHILL,
Corps of Engineers, U. S. A., Baltimore, Md.

UNITED STATES ENGINEER OFFICE, 2425 K STREET,
Washington, D. C., January 20, 1872.

MAJOR: I have the honor to state that, in compliance with instructions received from you, I have completed a survey of Neabsco Bay, Virginia, and I submit herewith my report, accompanied by a tracing from the original chart of the survey.

I was assisted in the survey by Messrs. J. E. Weyss and G. Thompson, the party consisting otherwise of seven laborers and boatmen.

The method of survey, taking of soundings, keeping of tide-gauge, &c., was in every respect similar to the plan adopted in the survey of Aquia Creek, a description of which is given in the report upon the latter.

The survey was commenced upon the 21st and finished on the 25th of July last, five days being occupied on it. Total length of shore-line run, six and three-fourths miles; number of occupied stations, 230; number of angles read, 649; number of soundings, 592.

Neabsco Bay is an estuary of the Potomac River, and empties into the latter at a

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point about twenty-eight miles below Washington City. It is located in Prince William County, Virginia, and is in the collection-district of Alexandria.

The characteristics of this stream are similar to those of the other creeks in the vicinity: expanding near its mouth to a wide bay, while at the upper portion of its course the channel becomes more contracted, and winds its way through large flats and marshes, the latter being covered with rank marine vegetation. The bottom is of soft mud, into which a pole can be easily pushed to a depth of 8 feet or more by a single man. The banks of the stream are hilly, and are mostly heavily timbered. The soil is tolerably fertile, and capable of being made fine farming-land. The population is sparse, the occupation of the people being principally farming and lumbering.

The exports from Neabsco consist almost solely of wood and lumber. The amount exported is estimated at one million feet of timber, and 3,000 cords of wood, with large quantities of hoops, staves, &c., annually.

This quantity would doubtless be largely increased were it not for the difficulties experienced in the navigation of the stream.

Most of the wood is brought down the creek in small quantities on lighters, and there reshipped on schooners in waiting at the mouth. This delay and rehandling vastly increase the cost of transportation. As an example, I am told that good standing wood, within a reasonable distance from the water, can be purchased for $1 per cord. The cost of cutting is but slight, but the cost of transportation to market leaves but a slight margin for profit.

The Baltimore and Potomac Railroad, in course of construction, which crossed Neabsco at the point indicated on the chart, has had a beneficial effect upon the vicinity. A new post-office has been established, known as Neabsco Mills, and a new highway leading from the telegraph road is about to be opened.

A steam saw-mill is in course of erection near the point indicated as Willis's Landing. It is expected that this new mill will be in operation on the 1st of June next.

I transmit with this report a letter from Mr. E. M. Willis, (the enterprising proprietor of the proposed mill,) concerning the opportunities for development which the surrounding country possesses.

A comparatively small expenditure on the part of the General Government in improving the channel of Neabsco Bay and Creek would, no doubt, add a great impetus to the enterprise which is beginning to manifest itself in this vicinity. A channel 4 feet in width at bottom, and 6 feet in depth at mean low water, from the mouth of the bay to the point where the deeper water below Atkinson's Landing commences, would seem to be all that is necessary at present. The course which I would recommend for such a channel is indicated in blue lines on the accompanying tracing. I would also recommend the adoption of the plan for protecting the channel by means of wattling, as proposed for Aquia Creek. The opening of such a channel, as proposed, would require an excavation of 38,073 cubic yards.

The following estimates are herewith submitted as the cost of the proposed improvements:

Excavating 38,073 cubic yards of material, at 20 cents	$7,614 60
Wattling, 836 rods, at $2	1,672 00
Add for contingencies, superintendence, &c., 10 per cent	928 60
Total	10,215 20

In conclusion, I beg to acknowledge my appreciation of the valuable services of Messrs. Weyss and Thompson during the survey.

As this was the last of the five Potomac bays and creeks surveyed by the party under my immediate supervision, it may be proper for me to state here that from the 19th of June till the 25th of July (the time occupied by these surveys) the weather was extremely hot, and the localities were unhealthy.

Sickness was around us, and even attacked our party. I feared that we would be obliged to put off the work till later in the season; but, thanks to the energy and cheerfulness of the whole party, I had the satisfaction of seeing all our contemplated work thoroughly completed before we were transferred by your orders to a more pleasant and healthy field of operations.

I am, major, very respectfully, your obedient servant,

CHAS. B. PHILLIPS,
Captain of Engineers, U. S. A.

Major W. P. CRAIGHILL,
Corps of Engineers, U. S. A., Baltimore, Md.

NEABSCO MILLS, VIRGINIA,
Fortsmouth 5, 1872.

GENTLEMEN: In considering the practicability of improving the several tributaries

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of the Potomac, I wish to give you a brief statement of one of them, *i. e.*, Neabsco Creek, together with some of the advantages to be derived from obtaining better communications.

There are now exported annually over 3,000 cords of wood, fully 1,000,000 feet of timber of various kinds, with thousands of hoops, staves, cedar-posts, &c.

With a deepened channel we can fully double the quantity of material already shipped; it will give us margin to develop the immense slate-quarries, only one mile from head of tide-water, which will undoubtedly yield a considerable of the roofing for our large cities on the sea-board; for schooners can then lie at our wharves and take in their loads, thereby saving us the extra cost of handling two or three times.

We have a soil bordering this stream capable of producing nearly all the grasses, grains, fruits, &c., and with a cheapened mode of importing fertilizers we shall soon send forth live stock, hay, fruit, &c., in large quantities, and grain both in its raw and manufactured state.

There are many reasons why this country, almost under the shadow of the capital, to-day lies almost waste and depopulated; it is needless to recount them. We want to be accessible, when we are almost in sight of Washington, and, with the spirit of enterprise already manifesting itself, we shall soon show a country thickly peopled, richly productive, and abounding in all that makes a community prosperous and intelligent.

To-day the right and left banks of the Potomac present to the eye the appearance of an unbroken wilderness; a striking contrast to the lands bordering many other rivers not capable of floating vessels of half the size that navigate it. Is it not time that something is done to induce the settlement of all this broad domain, and make a garden-spot of its shores?

E. M. WILLIS.

SENATE COMMITTEE ON COMMERCE.

UNITED STATES ENGINEER OFFICE, 2425 K STREET,
Washington, D. C., January 20, 1872.

MAJOR: I have the honor to state that in compliance with orders received from you I have completed surveys of Quantico and Choppawamasic Bays, Virginia, and I submit herewith my report, accompanied by tracings from the original charts of the surveys.

I am induced to embody the survey of the two bays in a single report on account of their close proximity, and on account of the common interests centering in the two. I had also designed plotting the two surveys together, but their different courses cause it to be inconvenient to plot them upon a single sheet.

I was assisted in these surveys by Messrs. J. E. Weyss and G. Thompson, the party consisting otherwise of seven laborers and boatmen.

The plan of survey adopted was in every way similar to that followed at Aquia Creek, a description of which is given in the report upon the latter.

The survey of the Choppawamasic was commenced on the 8th of July and finished on the 13th of July last, five days being occupied on it. Total length of shore-line run, six and one-half miles; number of occupied stations, 210; number of angles read, 624; number of soundings, 736.

The survey of Quantico Creek was commenced on the 14th of July and finished on the 20th of July last, six days being occupied on it. Total length of shore-line run, nine miles; number of occupied stations, 326; number of angles read, 1,020; number of soundings, 495.

Quantico and Choppawamasic Bays are estuaries of the Potomac River, and empty into the same at points about forty miles below Washington City. They are both located in the collection district of Alexandria. The two are separated from each other by a narrow neck of land about half a mile in width at their mouths. Passing back from the Potomac, the creeks separate and include a large tract of land between them.

It is upon this tract that the principal interests of the two bays or creeks concentrate. The importance of the territory embraced between the two creeks is, in the main, prospective.

The extension of the Richmond, Fredericksburgh and Potomac Railroad, now nearly completed, crosses the Choppawamasic, and finds its new terminus at the mouth of Quantico.

A bill at present before the Virginia legislature, concerning the charter of the Potomac and Manassas Railroad, will, if passed, it is claimed, cause this point to be the great outlet to tide-water for the coal of Western Virginia.

The Baltimore and Potomac Railroad has graded its track as far south as Quantico,

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and the site of a proposed bridge across the latter has been decided on. Its position is indicated on the accompanying map.

I transmit with this report a copy of a letter from Anson Bangs, esq., (a gentleman largely interested in property adjoining the two creeks in question,) in which he exhibits the prospective importance of the locality.

I will now proceed to consider the interests of the two bays individually.

Quantico Bay was in early days of considerable importance. The old town of Dumfries, situated in Prince William County, Virginia, and some four miles from the Potomac, was formerly possessed of considerable shipping, some of it even being engaged in foreign trade. For reasons unknown to the writer, the town fell gradually into decay; its channel was neglected and became filled up, and now it presents the appearance of a dilapidated village, with no shipping except flat-boats and an occasional light-draught schooner engaged in the shipment of wood. The banks of Quantico are quite heavily timbered. I have been unable to ascertain with any degree of certainty the amount of timber and wood shipped annually. From the appearance of the few wood-landings on its shores, I should judge that 1,000 cords per year would fully cover the amount shipped. Small quantities of hoop-poles, staves, &c., are also brought out of the creek.

There is no doubt but that this amount would be largely increased were the navigation of the creek to be improved; but not, in my opinion, to such an extent as to warrant the expenditure on the part of the General Government of the sum sufficient to excavate a channel, even only 5 feet in depth, for a distance of over two miles.

Concerning the bay proper, at the new landing of the terminus of the Richmond, Fredericksburgh and Potomac Railroad extension, it will be perceived that there is 8 feet of water at mean low tide. This seems to be sufficient for the wants of the company, for they might, by a slight extension, obtain a depth of 12 feet, if they wished, as will be seen by the chart. Boats drawing 7 feet can, at low water, pass beyond the proposed crossing of the Baltimore and Potomac Railroad, which seems to be sufficient for present wants.

Under these circumstances it would seem to be injudicious on the part of the Government to attempt any improvement at Quantico Bay or Creek at present.

Choppawamasic Bay and Creek form the dividing-line between Prince William and Stafford Counties, Virginia. It does not differ materially in its characteristics from the neighboring creeks.

A wide expanse of bay, with no well-defined channel, farther up the stream becomes more contracted, with deeper water; and again, still farther up, the stream, dividing, becomes lost amid a mass of water-plants.

The bottom consists of soft mud. The banks are heavily timbered. I have been unable to ascertain the exact amount of wood shipped annually, but it is probably less than 1,000 cords. A quantity of hoops and staves are also shipped from here.

It is probable that the operation of the new line of railroad, (extension of the Richmond, Fredericksburgh and Potomac Railroad,) which crosses the creek at a point about half a mile from the Potomac, will have a tendency to add to the importance of the navigation of Choppawamasic Creek.

A glance at the accompanying map will instantly suggest to the mind an extremely simple method of improving the navigation of the creek; a method which might be adopted at comparatively slight expense, which would materially shorten the distance from the Potomac to the railroad-crossing, and which, moreover, would have the merit of being a plan to assist nature in a work which she is trying to perform.

I refer to the opening of a cut across from the creek to the Potomac, forming a new mouth at a point about one-half mile from the present mouth. The point to which I refer will be detected by a glance at the map. A section from the creek across to the deep water of the Potomac is shown on the map.

At high tide a considerable amount of water flows in and out over this bar, and our party frequently took our small boat through to avoid the longer distance around to the mouth proper.

The cutting of a channel across this narrow neck of land would interfere with no private interests, and it would afford a tolerably fair refuge for shipping, as asked for in the letter of Mr. Bangs, referred to above, and which accompanies this report.

I would recommend that the removed material be deposited in the creek itself at a point about 300 yards below the proposed cut, where shallow water first commences. This plan would tend to force all the water out of the proposed cut, and keep it open, besides leaving a pocket below the cut, with 10 or 12 feet of water, where small craft might remain with safety.

On the map is shown the direction which I would recommend for the proposed cut. The material to be removed is a hard beach-sand, with some small bowlders.

I submit herewith estimates for the excavation of a cut 80 feet in width at bottom, and 10 feet in depth at mean low water. Also, for a cut of the same width, but with 12 feet of water.

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For a cut with 10 feet of water, (mean low tide.)

Excavating and removing 15,785 cubic yards of material, at 40 cents per yard	$6,314 00
Add for contingencies, superintendence, &c., 10 per cent	631 40
Total	6,945 40

For a cut with 12 feet of water, (mean low tide.)

Excavating and removing 21,643 cubic yards of material, at 40 cents per yard	$8,657 20
Add for contingencies, superintendence, &c., 10 per cent	865 72
Total	9,522 92

No other improvement seems to be called for at Choppawamasic Bay or Creek.

I beg to express my thanks to Messrs. Weyss and Thompson for the efficient aid which they rendered during the prosecution of the survey herein referred to.

I am, major, very respectfully, your obedient servant,

CHAS. B. PHILLIPS,
Captain of Engineers, United States Army.

Major W. P. CRAIGHILL,
Corps of Engineers, United States Army, Baltimore, Md.

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305 CARLTON AVENUE,
Brooklyn, January 4, 1872.

SIR: Your letter of the 2d instant has just been received. I will endeavor to comply with your request, and place before you, for information, the completed and contemplated improvements.

First. The extension of the Richmond and Fredericksburgh and Potomac road to the mouth of Quantico Creek is about completed. On its completion a large amount of freight will be received for Fredericksburgh and Richmond from the New York, Boston, and Philadelphia steamers. It will also be the principal shipping-point for Fredericksburgh.

We expect that a large portion of Richmond flour for South American ports can and will be sent by rail to Quantico for shipment.

Second. If the bill now before the Virginia legislature becomes a law, it can be reasonably expected that the road will be extended to the coal-fields in Hardy and Mineral Counties of West Virginia, thereby making Quantico Creek a great coal-depot. On the completion of the Chesapeake and Ohio Railroad, tide-water can be reached at Quantico and Choppawamasic, with less distance than at any other point in Virginia, consequently this point must eventually command a large portion of the business over the Chesapeake and Ohio Railroad, that goes to and from tide-water. This road is expected to be completed within the year.

Suitable arrangements should be made for dredging the Choppawamasic and Quantico Creeks to admit vessels drawing not less than 15 feet of water. The dredging of one of the creeks is required as a harbor for vessels from ice.

Yours, respectfully,

ANSON BANGS.

Captain CHARLES B. PHILLIPS,
United States Engineers, Washington, D. C.

Q 20.

NORFOLK HARBOR AND ELIZABETH RIVER.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, January 31, 1872.

GENERAL: A survey or examination of Elizabeth River and the har-

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bor of Norfolk, Virginia, was ordered in the appropriation bill for the improvement and survey of rivers and harbors, approved March 3, 1871.

The field-work was taken in hand as soon as other requirements permitted, and was executed in the months of September and October, 1871, under the immediate supervision of Captain C. B. Phillips, Corps of Engineers, zealously and intelligently assisted by Mr. J. E. Weyss and Mr. Gilbert Thompson.

Other duties, which could not be postponed, delayed the completion of the office-work until this time. The reports of Captain Phillips, dated January 30, 1872, are submitted herewith, with documents and maps, as stated therein.

Captain Phillips suggests a plan of improvement for Elizabeth River, which would give a depth at low water of 7 feet, as high up as the lock of the Albemarle and Chesapeake Canal. The estimated cost is $18,000.

As the tide rises nearly 3 feet, this additional depth could be then had at high water each day.

If Congress should decide to make an appropriation for the Elizabeth River, the plan of improvement indicated by Captain Phillips would be judicious. I think, however, the work would be found somewhat more extensive than his estimates contemplate, and would cost not less than $25,000. If the improvement is to be undertaken, it would be a decided economy to have the whole sum appropriated at one time.

The business of the canals of which the Elizabeth River is the outlet, especially the Albemarle and Chesapeake Canal, has increased notably in the past year, as shown by extracts given below from the last annual report of the president of that company, Mr. Marshall Parks:

> The Elizabeth River is navigable for vessels from Norfolk to the locks of the canal for vessels drawing 8 feet at high tide. The rise of tide averaging 3 feet, it is therefore quite impossible for vessels drawing more than 5 feet to go up to the locks at low water; hence a delay of a few hours often occurs in reaching the canal, interfering with the regular departure of steamers from Norfolk. To make this channel sufficient at low water, will require an improvement of the river, and it is hoped the recommendation made by the United States engineers, who are now making an instrumental survey of the river, will induce Congress to make the necessary appropriations for its improvement.
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>
> The lock has worked well, and, from its peculiar construction, so well adapted to the trade, rafts half a mile in length pass through it without being disconnected. The time and expense saved to lumbermen by this arrangement are appreciated by them. The gates, which have been in use ever since the construction of the canal, have had slight repairs during the past year, but are now in a questionable condition. Arrangements have been made for building two pairs, and if, on taking the others out, it is found that by repairing that portion above water, and the part more exposed to decay, they can be repaired, they may be restored without very great additional expense. It is proposed, at the first favorable opportunity, to build gates of iron, as being more durable. As no iron lock-gates are used on the canals of this country, we shall, if we introduce them, be the pioneer in this, as we have been in so many improvements.
>
> This canal is the only one in this country on which steam is used exclusively. The legislature of the State of New York, at its last session, offered a reward of $100,000 to any party that would introduce steam as a motive-power on the Erie Canal, in a manner that would prove as economical as horse-power, and attain a higher rate of speed. Such a large reward has stimulated the inventive genius of our people, and hundreds of plans have been suggested, not one of which, to this time, has accomplished greater results than are now attained on this canal.
>
> When the Albemarle and Chesapeake Canal was projected as a steam-canal, *with no tow-path*, its projectors were looked upon as visionaries. The result of their labors has proved the soundness of their judgment. More than 35,000 vessels have passed through their canal propelled or towed by steam, no animal-power having been used.
>
> The inland navigation, extending from the sounds of North Carolina to Baltimore, Philadelphia, and New York, continues to attract the attention of shippers. Efforts are being made to induce capital to embark in the establishment of a steam tow-boat

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line, with suitable barges, to run from all portions of Eastern North Carolina and Virginia to Norfolk; thence by inland route to the great Atlantic cities. It is believed the expense of transportation can be reduced below that of sail-vessels. The great increase of the traffic in lumber, railroad-ties, shingles, staves, corn, naval stores, telegraph-poles, and heavy ores, makes the establishment of such a line a necessity.

During the past year many enterprising lumbermen have purchased largely of timbered lands in Eastern North Carolina, bordering on the creeks and rivers, and have gotten out a vast quantity of mill-timber, which has been rafted to the North. This business is destined to create a revolution in the lumber-trade. The towing through the sounds and up the Chesapeake Bay has been done with economy and safety. In fact, the loss has been far less than on the Susquehanna River.

The business of the canal has steadily increased, not so rapidly as we could wish, but still there has been a steady increase, notwithstanding there has been no addition to the population of the country.

Immigration has not set in. The Northwest still continues to attract foreigners. Until some concerted movement is made to induce immigration to the South, its superior advantages in climate, soil, and markets will not be appreciated. Eastern North Carolina presents inducements to settlers which need only be known to prove attractive. The country adjacent to this canal embraces a territory as large as all the New England States together, excepting Maine, and has a navigation exceeding 1,800 miles in extent, offering easy and rapid communication to the principal markets of the country. If these *facts* were known to the emigrant, the population of this section would be augmented to double its present number before another decade.

The increase in cotton during the past year has been 9,562 bales; fish, 5,924 barrels; peas and beans, 3,167 bushels; potatoes, 7,215 bushels; wheat, 987 bushels; timber and sawed lumber, 674,593 feet; shingles, 15,529,400; staves, 134,000; fresh shad, 200,000; water-melons, 23,600.

The following articles decreased: Naval stores, 5,256 barrels; corn, 64,700 bushels; railroad-ties, 11,824; wood, 5,252 cords.

There has been a considerable increase in articles not heretofore mentioned, viz: Juniper, poplar, and beech logs—rafts, 49; 1,967 cords; peaches, 8,335 boxes; passengers, 3,813.

The number of vessels going north was 2,471; south, 2,429; total, 4,900, composed as follows: Steamboats, 1,656; schooners, 944; sloops, 555; barges, 183; lighters, 1,030; boats, 483; total, 4,900.

The tolls north and south last year were $47,662.56; this fiscal year, $55,778.72—a gain of $8,116.16. The towing last year was $10,567.61; this year, $8,806.77, making a loss of $2,760.79.

* * * * * *

Norfolk County has of late years been a garden for New York and other large cities. The rapid and frequent steam communication centering at Norfolk City has great facilities for the transportation of early fruits and vegetables to the northern markets. Such has been the rapid growth of this business that, to accommodate it, steamships are daily departing for Baltimore, Philadelphia, New York, and Boston.

Lands contiguous to the city of Norfolk, which, before the development of this business, did not command over $10 to $20 per acre, are now selling from $300 to $1,000 per acre.

The lands along the line of the canal in Virginia, and those upon North Landing River and Currituck Sound, North Carolina, convenient to navigation, may become equally as valuable, because they can produce vegetation from five to ten days earlier than Norfolk, and they possess facilities for reaching the market by water, which is less expensive and better than land transportation.

*

The report of Captain Phillips points out several changes in the condition of the harbor of Norfolk since the last map by the United States Coast-Survey. He gives satisfactory explanations of the probable causes of those changes, which deserve attentive consideration as well upon the part of the authorities of the United States as of the State of Virginia, and the cities of Norfolk and Portsmouth, in order that the causes of injury of the same kind may be guarded against in the future. The channel has shoaled to some extent opposite the mouth of the Western Branch.

The sum of $30,000 could be advantageously expended in the next fiscal year in improving the approaches from the sea to the harbor of Norfolk, should Congress deem it expedient to make such appropriation.

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Estimates.

Elizabeth River	$25,000
Norfolk Harbor	30,000

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. Army, Washington, D. C.

UNITED STATES ENGINEER OFFICE, 2425 K STREET,
Washington, D. C., January 30, 1872.

MAJOR: I have the honor to state that, in accordance with instructions received from you, I have completed a survey of the Elizabeth River, Virginia, and I submit herewith my report, accompanied by a tracing from the original chart of the survey.

I was assisted in the survey by Messrs. J. E. Weyss and G. Thompson, the party consisting otherwise of seven laborers and boatmen.

The Elizabeth River unites with the James and Nansemond Rivers in forming that magnificent estuary of Chesapeake Bay known as "Hampton Roads."

The three branches of the Elizabeth River are known respectively as the Southern, Eastern, and Western Branches, of which the first is the most important.

At the confluence of the Southern and Eastern Branches (about seven miles from the mouth of the river) are located the important cities of Norfolk and Portsmouth, the former on the right, and the latter on the left bank.

A survey of Norfolk Harbor having been ordered and completed, and a map and report upon the same having been prepared, I shall in this report confine myself to the Southern and most important branch of the Elizabeth River above the United States navy-yard.

The sheet accompanying the report on Norfolk Harbor shows that portion of the river below the confluence of the three branches, the Eastern and Western themselves, and also the position of the United States navy-yard referred to above. The various interests connected with these localities are touched on in the report upon Norfolk Harbor I have adopted this plan in order to avoid a set of disjointed sheets.

Referring, then, to the Southern Branch alone, this survey was undertaken in conjunction with the survey of Norfolk Harbor, the point of operations for each day being decided by the state of the weather.

The survey was accomplished between the 27th of September and the 31st of October last, eighteen days in all being occupied on the survey.

The low and marshy condition of the shores compelled a resort to triangulation at various points, the chain being called into requisition whenever its use was possible.

Total length of shore absolutely run by chain, seven and a quarter miles; number of occupied stations, 166; number of unoccupied stations, 157; number of angles read 1,729; number of soundings, 8,708.

Tide-gauges were kept at four different points on the river, and mean low-water mark established as accurately as possible.

All soundings on the accompanying chart are reduced to this reference.

It may be properly remarked in this connection that the result of our observations for mean low water varied but very slightly from that established by the Coast-Survey in 1866.

A remarkable fact connected with the tide in the Elizabeth River is, that the ordinary rise at the upper portion of the stream (at Albemarle and Chesapeake canal-lock is nearly as much as at the mouth, being about three feet at latter and 2.7 feet at the former point. The rise of the tide at the upper portion of the stream varies considerably, however, with the prevailing winds.

The Southern Branch derives its chief importance from the fact of its being the principal outlet for the commerce of Northern and Eastern North Carolina.

Two canals connect this river with the waters of Albemarle Sound, North Carolina.

The Dismal Swamp Canal, locking into the Elizabeth at a point about six miles above Norfolk, connects with the head-waters of Pasquotank River, North Carolina, which empties into Albemarle Sound.

The Albemarle and Chesapeake Canal locks into the Elizabeth at a point about eight miles farther up the stream, and connects with North Landing River, an affluent of Currituck Sound, North Carolina.

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These canals open up an immense line of inland navigation, and about twenty counties in North Carolina find this their most convenient outlet.

Over the line of the Dismal Swamp Canal there were passed, during the year ending September 30 last, about 8,000 tons of inward or northern freight, and about 10,000 tons of outward or southern freight. Total receipts of the canal from tolls on the above, between $12,000 and $13,000, For details concerning this amount of freight I refer to the annual report of the president and directors of this company for the year ending September 30 last. A copy of that report accompanies this. I also append a copy of a memorial of the Dismal Swamp Canal Company to the Senate and House of Representatives of the United States, dated December 20, 1871.

The General Government is largely interested in the stock of this canal.

A still larger amount of trade is carried on over the line of the Albemarle and Chesapeake Canal. During the year ending September 30, 1871, 4,900 trips were made through this canal by steamers, sloops, and craft of all kinds.

The total amount of tolls accruing to the company from this traffic amounted to about $56,000, a gain of over $8,000 above that of the previous year.

For the details of this trade I refer to the reports of the president and directors of the canal company for the years ending September 30, 1870 and 1871, respectively. These printed reports are herewith appended.

Below the lock of the Dismal Swamp Canal no difficulty is experienced in the navigation of the Elizabeth River. A deep and unobstructed channel exists up to this point, and, in fact, to a point about two miles further up the river.

The above remark should be qualified by stating that the Norfolk and Petersburgh Railroad bridge, which crosses the river about three-fourths of a mile above the Dismal Swamp lock, causes considerable annoyance to shipping, much of which is taken up and down the river in long tows. As many as five schooners sometimes constitute a single tow.

The draw of the bridge referred to is badly located. It is nearly over to the right bank of the river, away from the deepest water, and out of the course which shipping would take were it not for the bridge.

This evil, however, it appears, must continue to exist, as litigation has, I understand, failed to correct the matter.

Near Deep Creek, about five miles below the lock of the Albemarle and Chesapeake Canal, we first encounter water so shoal as to incommode the class of shipping which comes through the canal. From this point up, several shoals are encountered, and also a few turns in the course of the channel, so abrupt as to seriously interfere with the tows.

In the present state of the river, but 5 feet of water can be depended upon at all stages of the tide up to the upper lock.

The increasing trade would seem to call for at least 7 feet at mean low water.

With this depth of water the capacity of the shipping might be increased, and the delay which is now experienced in waiting for high water be avoided.

A considerable amount has been expended from time to time by this company in deepening the channel at particularly bad points; and one point has been cut off, where the turn in the channel was particularly abrupt. This latter point will be perceived by a glance at the map. This cut has worked well; the water in it has maintained its original depth, and the old channel is filling up.

In case of any contemplated improvement of this river, I would recommend two additional cut-offs.

These proposed cut-offs are marked "A" and "B" on the chart accompanying.

In my estimates I have calculated for a channel sixty feet in width at bottom, and seven feet in depth at mean low water.

On the chart I have indicated in blue lines the course which I would recommend for such a channel over the shoals and also across the two points.

The material to be dredged consists almost solely of sand, especially at the cut-offs. In the bed of the river a small proportion of mud is found.

A plenty of room for depositing the material can be found at the old bends of the river, which would become neglected. Probably half of the removed material at the cut-offs could be deposited directly upon the banks.

The following estimates are herewith submitted as the probable cost of carrying out the improvements suggested above:

Excavating and removing amount of material as follows:

	Cubic yards.
At proposed cut-off "A"	10,704
At proposed cut-off "B"	16,760
Aggregate amount at shoals	13,356
Total	40,820

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40,820 cubic yards of material, at 40 cents	$16,328 00
Add for contingencies, superintendence, &c., 10 per cent	1,632 80
Total	17,960 80

In conclusion, I beg to express my thanks to Messrs. Weyss and Thompson for the energy and ability which they displayed while engaged in the prosecution of this survey.

I am, major, very respectfully, your obedient servant,

CHAS. B. PHILLIPS,
Captain of Engineers, United States Army.

Major W. P. CRAIGHILL,
Corps of Engineers, United States Army, Baltimore, Maryland.

UNITED STATES ENGINEER OFFICE, 2425 K STREET,
Washington, D. C., January 30, 1872.

MAJOR: I have the honor to state that, in accordance with instructions received from you, I have completed a survey of Norfolk Harbor, Virginia, and I submit herewith my report, accompanied by a tracing from the original chart of the survey.

As stated in my report upon the survey of the Southern Branch of the Elizabeth River, the chart accompanying this report exhibits the lower portion of the river, (below Norfolk Harbor proper,) and so much of the Southern Branch as to include the United States navy-yard above Portsmouth.

For purposes of comparison, I have put upon this sheet (in a different color) the soundings as given by the most recent coast-surveys. Our own soundings are in blue; those of the Coast-Survey in black.

All these Coast-Survey soundings were taken as far back as 1854, excepting opposite the navy-yard. The latter were taken in 1866. Only the most characteristic soundings have been put on this sheet, in order to avoid confusion; and it is trusted that the plan adopted will prove of service in studying the changes which have taken place in Norfolk Harbor during the last seventeen years.

I was assisted on the survey by Messrs. J. E. Weyss and G. Thompson, the party consisting otherwise of seven laborers and boatmen.

The survey was undertaken in conjunction with that of the Southern Branch, the point of operations for the day being decided by the weather, the calmer and more favorable days being taken for soundings in the harbor and at the lower part of the river.

The survey was accomplished between the 27th of September and the 31st of October last, twelve days in all being occupied on the survey.

From the navy-yard to the lower part of the city, the shores and wharves were put in by careful triangulation. Below the city a considerable portion of the shore-line was run in by the chain. A tide-gauge was established at the light-house opposite Norfolk, and carefully observed. A few observations for tide were also made at Craney Island. Nearly at the close of our observations we learned from the Coast-Survey their bench-mark for mean low water at Norfolk Harbor. On referring to it we found that the low water established from our observations was almost identical with that of the Coast-Survey.

Total length of shore-line run, five and one-eighth miles; number of occupied stations, 68; number of unoccupied stations, 59; number of angles read, 809; number of soundings, 5,577.

The city of Norfolk, Virginia, is located on the right bank of the Elizabeth River, at the confluence of the two branches known as the Southern and Eastern. The advantages which the city enjoys as a sea-port are too well known to need more than a passing notice here. Her central position on the Atlantic sea-board; her mild climate, and consequent freedom from obstructions to navigation from ice, and her facilities for communication with a fertile and productive interior, give her natural advantages almost unsurpassed.

The harbor proper, (or that portion of the river opposite the city,) although somewhat contracted, has, nevertheless, a good depth of water; while below, the city has opportunities for an almost indefinite expansion of her water-front.

The city of Portsmouth, Virginia, is located opposite to, and a little above Norfolk. More properly speaking, it is situated on the left bank of the Southern Branch of the Elizabeth. Her interests are, to a great extent, identical with those of Norfolk, and she possesses, in a less degree, the same natural advantages.

Immediately above the city of Portsmouth, and on the same side of the Southern Branch, is the United States navy-yard, known as the Gosport yard. This navy-yard

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has not yet regained the importance which it had before the late war; but its fine natural advantages will, doubtless, at some time, make it again an important naval station; and the General Government must necessarily always be particularly interested in the preservation of the channel below.

The population of Norfolk, according to the census of 1870, was 19,229, an increase of 4,609 during the previous ten years.

The population of Portsmouth in 1870 was 10,492, an increase of 1,004 during the previous ten years.

The main lines of communication between Norfolk and the back country are the Southern Branch of the Elizabeth River, the Norfolk and Petersburgh, and the Seaboard and Roanoake Railroads.

The Southern Branch is connected with the waters of Albemarle Sound, North Carolina, by means of two canals—the Dismal Swamp and the Albemarle and Chesapeake. These two canals make tributary to Norfolk the produce and trade of some twenty counties in Northern and Eastern North Carolina; and have been referred to more particularly in my report to you of this date, concerning the survey of the Southern Branch.

The Norfolk and Petersburgh Railroad was completed in 1858. It suffered severely during the late war, but has since recuperated to a great extent, and is now, by means of its connections, an important outlet for the produce of a great tract of country, particularly of the tobacco region in the vicinity of Lynchburgh.

The Seaboard and Roanoake Railroad has its tide-water terminus at Portsmouth. This road is a link in the chain of passenger communication from Baltimore to the South, and also opens up a considerable trade between Norfork and the interior of North Carolina.

Norfolk is the terminus of a line of ocean-steamers to each of the following ports, viz: New York, Boston, and Philadelphia. The bay steamers connect by a daily line with Baltimore, Maryland, and there is also a tri-weekly communication by steamer with Washington, D. C. Various lines of river-steamers also connect Norfolk with Richmond, Yorktown, Cherrystone, and Hampton, Virginia, and various points in North Carolina.

An idea of the amount of the foreign trade of Norfolk will be gained by a glance at the statistics given below. I am indebted to Luther Lee, jr., esq., the courteous collector of customs at the port of Norfolk, for this information.

List of tonnage, crew, and number of vessels entered and cleared (coastwise) at the port of Norfolk from January 1, 1871, to December 31, 1871.

ENTERED.

Tonnage	1,555,215
Number of crew	32,539
Number of vessels	1,455

CLEARED.

Tonnage	887,585
Number of crew	26,035
Number of vessels	1,003

List of tonnage, crew, and number of vessels (foreign) entered and cleared from January 1 to December 31, 1871.

ENTERED.

Tonnage	19,310
Number of crew	861
Number of vessels	18

CLEARED.

Tonnage	12,092
Number of crew	387
Number of vessels	24

List of tonnage, crew, and number of American vessels entered and cleared (foreign) from January 1 to December 31, 1871.

ENTERED.

Tonnage	2,714
Number of crew	50
Number of vessels	4

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CLEARED.

Tonnage	7,565
Number of vessels	32
Number of crew	340

Amount of duties collected at the port of Norfolk, Virginia, from January 1 to December 31, 1871.

Duties	$143,971 82
Hospital-tax	3,244 80
Tonnage-tax	4,572 60

On consulting the accompanying chart, for the purpose of comparing our soundings with those of the Coast-Survey, it will be perceived that a number of changes have taken place in the harbor during the past seventeen years.

I will briefly consider the most important ones. One of the most striking changes is at the entrance of the harbor proper, opposite the light-house. The water at this point has, it will be seen, gradually deepened toward the left bank of the river, while the water in the vicinity of the naval anchorage (opposite the light-house) has become correspondingly shoaled.

These changes are undoubtedly due wholly or in part to three distinct causes, viz: 1st. The sinking of hulks on the Norfolk side of the channel during the early part of the war; 2d. The prolonged stay of deep-draught naval vessels at the anchorage-ground referred to; and, 3d. The running out of wharves from the opposite or right shore. The hulks which were sunk here have been removed since the war. The anchorage is still used by naval vessels while discharging their powder, before proceeding to the navy-yard above.

Concerning the running out of wharves opposite this point, a precedent justifying the continued encroachment of the wharves upon the channel from the Norfolk side seems to have been established in the result of the recent case of litigation connected with Pfeifer's wharf. The injunction which was asked for, to prevent the building of this wharf, was not granted by the courts. A causeway 175 yards in length now extends out from the shore to nine feet of water. It is unquestionable that this wharf and causeway detract much from the benefit formerly derived from the scouring effect of Paradise Creek and the bay included between the wharf in question and Town Point.

If a "port-warden's line" has ever been established at this part of the harbor, it is possibly not known, but it is certainly not respected.

We find slight and rather peculiar changes in the bed of the harbor between the county bridge across the Eastern Branch and the confluences of the two branches. We find a slight tendency of the channel to deepen immediately and for some little distance below the bridge.

Further down (some 800 yards below the bridge) shoaler water, which, as far as is known, has always existed, is encountered, and continues until the influence of the Southern Branch is felt. The depth of the shoaler water referred to has changed but little since the soundings were taken by the Coast-Survey. It appears to have filled in very slightly. Its worst feature seems to be that the shoal is slowly extending along to the wharves immediately below the ferry. I attribute these changes to the existence of the county bridge across the Eastern Branch. The stream is considerably contracted at this point by a long causeway, which constitutes the southern extremity of the bridge.

This accounts, in my opinion, for the slight deepening immediately below the bridge, and also for the slight additional shoaling below, the removed material being deposited as soon as the wider portion of the stream is reached.

It will be perceived that a considerable deepening has taken place immediately at the confluence of the two branches. This would seem to be but the mere result of the changes just referred to, the gradual extension of the shoaler water near the ferry seeming to contract the width of the Southern Branch channel, and causing it to make deeper water.

From this point on toward the entrance of the harbor, and also in following up the course of the Southern Branch, the water in the channel seems to have pretty generally maintained its original depth.

The flats on the Portsmouth side have filled in to a considerable extent.

As stated above, the soundings opposite the navy-yard were taken by the Coast-Survey in 1866. A considerable amount of dredging has since been done there by the Government.

On the whole, the condition of the harbor of Norfolk does not appear to have materially deteriorated since 1854, and it appears to me that the apprehensions of the people concerning it are rather exaggerated.

The area of cross-section at the entrance to the harbor may have diminished; if so,

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but very slightly, and the capacity and average depth of the harbor appear to be fully as great as seventeen years ago.

It would be well for the city to make every effort to prevent the continued encroachment of the wharves, unless duly authorized and constructed in accordance with some intelligent system. And, while providing for the future, it would also be well, if possible, to get rid of those structures already in existence which tend to injure the condition of the harbor.

In my opinion, it would be injudicious on the part of the General Government to attempt any improvement of Norfolk Harbor at present.

In conclusion, I beg to express my thanks to Messrs. Weyss and Thompson for the energy and skill displayed by them during the prosecution of this survey.

I am, major, very respectfully, your obedient servant,

CHAS. B. PHILLIPS,
Captain of Engineers, United States Army.

Major W. P. CRAIGHILL,
Corps of Engineers, United States Army, Baltimore, Maryland.

Q 21.

NANSEMOND RIVER, VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, January 6, 1872.

GENERAL: A survey or examination of the Nansemond River, below Suffolk, was ordered in the appropriation bill for the improvement of rivers and harbors, approved March 3, 1871.

The field-work was executed by Mr. William Popp, assistant engineer. I transmit herewith his report, accompanied by a map in two sheets. His estimates contemplate making, by dredging, a channel over Suffolk Bar and Western Branch Bar of 100 feet in width and 8 feet in depth at low water; the construction of dikes at entrance of Western Branch Bar, and the removal of obstructions to navigation, such as wrecks, piles, fallen trees, snags, &c., at a total cost of about $30,000. This sum could be judiciously expended in a single year, should Congress decide to make an appropriation for the improvement of the Nansemond River.

It might be expedient, if the increase of trade justified, to increase the width of the dredged channel from 100 feet to 200 feet. This would add about $20,000 to the cost of dredging.

In connection with the maps of Mr. Popp's survey, reference is requested to the latest Coast-Survey maps and to a general map of that portion of the State of Virginia through which the Nansemond River flows.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

BALTIMORE, MARYLAND, *January* 6, 1872.

MAJOR: I have the honor to submit the following report on the survey of the Nansemond River, from Suffolk to its mouth, made by me under your direction, from November 1 to 23, 1871.

The manner in which the survey was conducted for the first seven miles of the river below Suffolk resembled that adopted on the Neuse River and detailed in my report on the survey of that river. Seven miles below Suffolk the river expands suddenly, and it became necessary to make a triangulation with the transit. All the prominent points on the river banks were thus located. The soundings were located by determin-

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ing both ends of each line run by the trilinear method, using the triangulation points for the purpose, and placing the intermediate soundings at equal intervals. This method of locating soundings was adopted because the small amount of funds available for the survey, and the extremely unfavorable condition of the weather during the progress of the survey made all possible haste desirable.

Before leaving Suffolk I had ascertained from good authority that the lower portion of the river was in a condition that did not make any improvement necessary or even desirable; that very slight changes were taking place in the location and depth of the channels. For this reason I did not deem it necessary to resurvey the portion of the river surveyed in the years 1854 and 1856 by the Coast-Survey. A suggestion made to that effect was approved by you in your letter dated November 17, 1871, and I therefore concluded the survey at Thomas Point, after making a good connection with the Coast-Survey work.

Tidal records were kept during the progress of the work at Suffolk for sixteen days. Mean low water was determined for this place from those observations, and mean rise and fall found to be 3.9 feet. Two simultaneous observations, at Suffolk and Sleepy Hole, gave a difference in time of low water of one hour; the distance from the former to the latter place on the river is twelve miles, and the velocity of the tidal wave for the portion of the river is therefore twelve miles per hour. The soundings were reduced to mean low water by assuming that the rise and fall of tide and the velocity of tidal wave were the same for every point of the river. This supposition is, of course, not strictly correct, but it was impossible to obtain a series of observations at short intervals along the river, from which the values could be determined more accurately.

The sides of all triangles were calculated and platted by distances. About one-half of all the soundings taken are platted on the charts; the topography represented was merely sketched by eye, but it is believed to be sufficiently correct.

The result of the survey may be summed up thus: From Suffolk to a point seven miles below it the river flows in a bed from 200 to 400 feet in width. Its course is tortuous; extensive marshes occupy the convex side of the river, while the concave side generally consists of steep bluffs of from 20 to 50 feet in height. The average depth of water in the channel ranges from 8 to 12 feet. The marshes are at the reference of high water, or a few inches above it. The river-bed consists almost exclusively of soft mud. On some of the sharper bends erosion of the steep banks is going on, and what are by the natives called "bank-slides" have taken place, and carried large trees into the river, thereby partly obstructing the channel.

The snags and fallen trees at the bank-slides just mentioned; two small wrecks; a bar at and just below Suffolk; the bar at the mouth of Western Branch, seven miles below Suffolk; and the blockade at the same place, constitute the obstructions which require removal or improvement.

The ruling depth of water in the channel, with the exception of the two bars above mentioned, is 8 feet. Nothing seems to be required at Suffolk Bar except dredging a channel of sufficient width and depth. At the Western Branch Bar, however, the case is different. From the inspection of the accompanying maps, it will be seen that two circumstances combine here to form the bar, viz, the sudden increase of the width of the bed of the Nansemond River, and the unfavorable angle of confluence. The latter creates something like a whirl; the former diminishes the velocity of the ebb tidal current very considerably. The velocity of the ebb-current I estimate to be about 1.75 feet per second in the upper portion of the river; at any rate, it is great enough to carry along in suspension great quantities of mud, which are chiefly deposited at this bar. Persons familiar with the river said that the depth of water on the bar had not decreased for the last twenty years. This fact they mentioned in support of their opinion that, if dredged to a sufficient depth, the channel would remain open. I have no reason to doubt the truth of this statement; but it proves nothing in reference to a proposed improvement. The bar has arrived at that stage where, in consequence of the reduction of depth of water, the velocity has been increased sufficiently to carry the suspended matter beyond the lower crest of the bar. The question, whether or not the bar was increasing in length, could not be answered by my informants. I was very anxious to obtain a series of current-observations at and in the vicinity of the bar, but rains and high winds, prevailing for several days, prevented me from determining anything except the direction of the ebb tidal current on the bar in the Western Branch.

In order to make a permanent improvement of the river at this place, it seems necessary to remedy both defects mentioned above, and for this reason I would propose to run dikes, as indicated on the accompanying map by red lines. Dike A is intended to correct the unfavorable direction of the current in Western Branch; B is to reduce the width of the bed within a proper limit. The channel to be dredged is kept at a sufficient distance from this dike not to injure its stability, although it is proposed to place the dike on the natural bed without dredging.

The portion of the Nansemond River from the Western Branch Bar to its mouth has the character of a rather wide estuary. The channel itself, however, is narrow, the

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greater portion of the bed being occupied by Oyster Pass. The depth of water in the channel ranges from 12 to 18 feet, and the only obstruction to navigation consists of about fifty piles, three miles from the mouth.

The Nansemond is, on the whole, a fine river. Its banks are high, the adjacent land is well cultivated, and a considerable trade is carried on by small sailing-vessels.

The principal trade is the oyster trade, in which hundreds of small vessels are engaged; the lumber trade is also very considerable, and the trucking business, which is now chiefly confined to the Seaboard and Roanoke road, would eventually assume very large proportions, if the river were navigable for steamers and large sailing-vessels.

The principal obstacle to the development of the trade on the river is the Western Branch Bar and blockade. The ruling depth of water over this bar is at present only 4 feet. The opening made since the war through the blockade is narrow and not buoyed out, and strangers are, for this reason, exposed to great risk. During my presence at the bar, I saw a large schooner fast on top of the piles of the blockade, and the little tug in which my party went up to Suffolk nearly got wrecked herself in the same place.

The tributaries of the Nansemond River are:

Shingle Creek, connecting Dismal Swamp with the river. Large quantities of shingles are shipped on this creek.

Burnett's Mill Creek, with an extensive wood and lumber trade.

Western Branch, from which considerable quantities of lumber and wood are shipped.

The principal town on the Nansemond River is Suffolk, which seems to be a very thriving and enterprising place.

Captain George W. Singleton, postmaster of Suffolk, had the kindness to compile a statement of statistical data, with reference to trade on the river, &c., which was signed by the most intelligent and influential business men of Suffolk. His statement is inclosed as Appendix A.

Probable cost of removing obstructions from Nansemond River:

Wrecks of two small schooners	$150 00
Dredging of channel on Suffolk Bar, 2,400 feet long, 100 feet wide at bottom, slopes 1 to 2, mean depth of dredging 1.5 feet=13,700 cubic yards, at 30 cents	4,110 00
Removal of 12 fallen trees, at $6	72 00
Removal of leaning trees	50 00
Dredging of channel on Western Branch Bar, 2,000 feet long, 100 feet wide, slopes 1 to 2, mean depth of dredging 3 feet=23,600 cubic yards, at 30 cents	7,080 00
Dikes, 400 linear feet, at $3.50	1,400 00
Removal of wreck of schooner, 120 feet by 18 feet, and 41 piles	600 00
Removal of 50 piles at lower blockade	75 00
	26,137 00
Contingencies, &c., 10 per cent	2,613 70
Total	28,750 70

The work is located near Norfolk and Fortress Monroe.

Amount of commerce and navigation benefited by the proposed improvement is estimated at $1,000,000.

All of which is respectfully submitted.

I am, major, very respectfully, your most obedient servant,

WILLIAM POPP,
Assistant Engineer.

Major W. P. CRAIGHILL,
Corps of Engineers, U. S. A., Baltimore, Maryland.

APPENDIX A.

SUFFOLK, *December* 1, 1871.

To Major W. P. Craighill, Corps of Engineers, U. S. A.:

The inhabitants of the town of Suffolk number 2,000. It has a large back country, with a local trade of $300,000 per annum.

Actual trade benefited by improvement of river, in lumber, trucking, and oysters, $1,000,000 per annum.

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The lands are adapted to trucking almost exclusively on the river, and for twenty miles on either side, being very productive and thickly settled.

NORFLEET BROTHERS, *Merchants.*	ESAU B. BRILL, *Merchant.*
WILLIS S. RIDDICK,	THOS. W. SMITH, *Merchant.*
BENJ. RIDDICK, *Merchant.*	WM. I. COHOON, *Merchant.*
JOHN R. COPLAND, *Cashier Bank.*	MR. JONES, *Merchant.*
JOHN J. PEINER.	WALLACE KILLY, *Merchant.*
E. F. WILLIAMSON.	GEO. W. SINGLETON, *Postmaster.*

Q 22.

ROANOKE RIVER, BELOW WELDON, NORTH CAROLINA.

BALTIMORE, MARYLAND, *December* 5, 1871.

GENERAL: I have the honor to submit herewith a report by Mr. George H. Elliott, under date of April 28, 1871, of his examination of the Roanoke River, below Weldon, North Carolina, made in November and December of 1870, and January and February of 1871.

Authority for the survey was contained in the appropriation bill approved July 11, 1870. Unavoidable difficulties arose to delay the commencement, the continuance, the completion, and the thoroughness of the examination. These are detailed in Mr. Elliott's report, now submitted, and in my preliminary report of January 17, 1871, which is printed in Executive Document No. 60, part 2, House of Representatives, Forty-first Congress, third session.

The small sum which could be allotted for the purpose and other circumstances made the examination rather a reconnaissance than a minute survey, but much valuable information has been obtained through the efforts of Mr. Elliott, enabling the preparation of estimates of the cost of improvement, which are submitted herewith.

A careful study of the map of the river, its capacities and requirements, indicated that from its mouth to Indian Highland Landing and Bar, a distance of about sixty-five miles, there existed already at all seasons a sufficient depth for vessels of a draught of water of about 10 feet, which is even more than is required for the trade through Albemarle Sound and the canal. A few troublesome wrecks were found in this portion of the river, which are now in process of removal, under a contract with Mr. Foote, of Plymouth; the funds therefor being derived from the appropriation of $20,000 for the improvement of this river, made by the act approved March 3, 1871. Two cut-offs have been proposed in this portion of the river, by each of which several miles would be saved. They are now impassable, even for a canoe, being obstructed by rafts, overhanging trees, and large accumulations of *débris*. We have not sufficient data for estimating the cost of opening them. This is a matter the less to be regretted at present, as there are localities whose demands for attention will be more pressing, if a methodical scheme of improvement be begun for the river. It may be expedient to take out some snags and fallen trees, but the funds already available suffice for this purpose. No estimate is, therefore, presented at this time for the improvement of the portion of the river between its mouth and Indian Highland Bar.

Above Indian Highland Landing, to Weldon, about fifty-five miles. the river is so variable in depth as not to afford a continuous low-water navigation of more than 2 or 3 feet. The section from Indian Highland Bar to Weldon will therefore be considered the only portion calling for any large expenditure for its improvement at this time. For this whole

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distance the stream winds tortuously through an alluvial region lined on either side with a nearly continuous fringe of timber.

The banks are generally sufficiently elevated, but in many places lined with overhanging trees. At one or two places small ledges of rock cross the stream, but the bed is generally sandy. Subjected to freshets, which attain a considerable elevation, the bed has by them been widened to such an extent that the volume of water in the river at low stage is insufficient to maintain a useful depth with the present width. In addition, the freshets annually sweep from the banks large numbers of trees, which are deposited along the river-bed, forming nucleuses for bars, rafts, &c. The peculiar succession of pools and shallows found throughout this section, without any apparent change in the nature of the bed, its hardness, width, and declivity, may be accounted for by the supposition that the gradual accumulation of sunken logs have formed dams, which are now covered with sand and gravel.

The length of the line requiring improvement, and its consequent cost under any plan, render it essential that the depth of water attempted to be maintained should be no more than is necessary to afford a continuous navigation from Weldon to Norfolk, Baltimore, &c. When it was proposed, in 1822, to improve this river, under the authority of the State of North Carolina, the engineer, Mr. Fulton, decided that 5 feet at low stages was enough. Mr. Elliott estimates that to give a low-water channel-way in the river, below Weldon, 60 feet in width and 5 feet deep, would require an expenditure of about $80,000. This sum should be increased by at least 75 per cent., or made $140,000, to include the improvement (by the same methods) of those bars, &c., which Mr. Elliott was unable to examine carefully, but whose general character is the same as of those he did examine. We may properly deduct from the sum last mentioned, viz, $140,000, the amount of the appropriation for this river under the act of March 3, 1871, $20,000, leaving $120,000 to be still provided.

It is, however, my belief that, owing to the causes mentioned already in this report, viz, the prevalence of frequent high freshets, and their effects on the bed of the stream, such an improvement as is contemplated by Mr. Elliott's estimate would not be permanent. The circumstances of the case seem to require a resort to the use of training-dikes, (of piles wattled with saplings,) in order to a contraction of the *low-water* width of the stream. By this expedient it is highly probable a low-water depth of 5 feet may be obtained and *maintained* without resort to dredging. The positions of the dikes, as proposed, are indicated on the maps herewith. An estimate is presented below for this method of improvement:

1. Removing snags, sunken logs, &c	$25,000
2. Removing rocks, &c., near Weldon	10,000
3. Training-dikes, 156,000 linear feet, at $1.50	234,000
Total	269,000

From which deduct amount yet unpledged of the appropriation of 1871, leaving to be still appropriated $259,000.

It has been suggested that the interests involved justify and demand the maintenance in this river, below Weldon, of a depth at all seasons at not less than 8 feet. To do so would probably require an additional expenditure of not less than $250,000. It is by no means certain that to obtain and maintain a depth of 8 feet is *possible*. To settle this ques-

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tion would require a very careful gauging of the stream, at all seasons, by observations extending over a long time.

If money is appropriated to maintain a depth of not less than 5 feet at all stages of water, it will be time enough, while that operation is in progress, for a careful collection of the data necessary to decide as to the propriety of attempting a greater depth.

The Roanoke River is situated in the collection-district of Albemarle, North Carolina, above Edenton, the port of entry, which is nearly opposite the mouth of the Roanoke River.

At the port of Edenton, for the fiscal year ending June 30, 1871, the revenue collected from all sources is stated by the collector to have amounted to $1,018.

Edenton is the only port of entry for its collection-district, but the following ports of delivery are situated on the Roanoke River, viz, Plymouth and Wilmington. Freight is shipped by steamer from and landed at Jamesville, Hamilton, Hill's Ferry, and other landings, including Weldon.

Collector Manning, in an interesting communication, says:

> The foreign import and export trade of this collection-district is small, but the coastwise trade is of considerable importance, as nearly all our products are shipped to the northern markets, and large freights of merchandise are constantly being transported to merchants, planters, and others doing business at various places on the Roanoke River. * * * * * * * * *
>
> It may safely be computed that the value of products carried out of the section of country bordering on the Roanoke River and its tributaries will annually amount to over $2,000,000, and the amount of merchandise purchased at the North and brought to that portion of this district will amount to over $1,500,000.

Papers are transmitted herewith, as follows, viz: Report of Mr. George H. Elliott, dated April 28, 1871; map of his survey, in six sheets; communication from Mr. C. G. Manning, collector at Edenton, North Carolina, dated August 7, 1871.

Respectfully submitted.

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, April 28, 1871.

COLONEL: In compliance with your instructions I have the honor to submit report on the survey of the Roanoke River, from Weldon to Plymouth, North Carolina, made under your direction during the months of November and December, 1870, and January and February, 1871.

The survey was commenced at Weldon, and followed the course of the stream to a short distance below Plymouth, or some six miles from the mouth of the river, where it empties into Albemarle Sound. From the commencement to the termination of the survey, freshets in the river were quite frequent, which not only interrupted and retarded operations, but rendered the survey incomplete at various points where critical examination was necessary, but could not be made owing to the high water.

The towns on the river below Weldon are Halifax, the county-seat of Halifax County, Palmyra, at Hill's Ferry Landing, Hamilton, Williamston, the county-seat of Martin County, Jamesville, and Plymouth, and are respectively distant from Weldon, following the course of the river, ten, fifty, sixty-eight, ninety-two, one hundred and ten, and one hundred and twenty-two miles. In addition to these towns there are numerous intermediate landings. With the exception of Weldon and Halifax, none of these places have any railroad communication, except at such distances as to make freights too expensive, and they are consequently dependent for their supplies upon the steamers running up and down the river. A railroad has been partially constructed to connect Williamston with Tarborough, distant thirty-eight miles, the terminus of a branch of

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the Wilmington and Weldon Railroad, but judging from the progress made in the past, it is not likely to be completed for some time.

Weldon, from the rocks and rapids in the river, is the limit of navigation from Albemarle Sound; it is situated in the county of Halifax, eighty miles distant from Norfolk, with which place it is connected by a railroad, and is chiefly important as being the common center of four railroads, viz, the Seaboard and Roanoke, Petersburgh and Weldon, Wilmington and Weldon, and Raleigh and Gaston. It has a grist-mill and an iron-foundery; the latter is almost exclusively devoted to the manufacture of plows and other agricultural implements, which are much used in the country adjacent to the Roanoke. These works derive their power from a canal, originally constructed to boat produce from above the falls; but as it is to a considerable extent filled up, it has not been used for this purpose of late years.

The falls afford a fine water-power, and the position of Weldon, within a short distance of and with easy access to the sea-board, in a country producing large quantities of cotton, where fuel is abundant and provisions can be readily procured, points it out as an admirable site for manufacturing purposes.

When the stage of water will permit, the steamer Silver Wave (load-draught 42 inches) makes regular trips twice or thrice a week down the river, from Weldon to Norfleet's Ferry, a distance of thirty-two miles, carrying supplies and bringing up the products of the country, to be shipped from Weldon, principally to the sea-board.

Below Weldon the Roanoke flows along the borders of the counties of Halifax, Northampton, Bertie, and Martin, and, near its month, Washington, a section of country of great fertility, which, previous to the war, produced large quantities of grain and meat. One planter alone shipped more than one hundred thousand bushels of corn annually, and several thousand hogs were every year driven and shipped from the country immediately on the river in Halifax County alone, principally to Virginia.

Since the war, owing to the almost entire destruction of the dams built to prevent the lowlands from inundation, only the highlands have been cultivated, and these almost exclusively in cotton, the quantity of cereals at present produced being inadequate to the wants of the inhabitants. In the lower country, extending some thirty-five to forty miles above the mouth of the river, the manufacture of shingles is carried on very extensively; it is estimated that from fifteen to twenty millions are made and shipped annually. Large quantities of timber are also gotten out and transported North to be manufactured into lumber.

Halifax, the county-seat of that name, is situated a short distance from the river on the west bank, ten miles below Weldon, and on the Wilmington and Weldon Railroad, over which most of the freight to and from Halifax is forwarded; it has no manufactories.

Five miles back from the river, at Smith's Landing, is the small town of Scotland Neck, where considerable business is done, which receives and forwards nearly all its freight by the river-steamers, it being twenty miles distant from the nearest railroad depot, Halifax.

Palmyra, one mile back from Hill's Ferry Landing, is situated on the boundary of Halifax and Martin Counties, on the west bank of the river, fifty miles below Weldon. The produce of a considerable portion of the back country is collected here for shipment to Norfolk by steamers, of which three to five leave weekly, except during the low-water stages, when they cannot come up as high as this point.

Hamilton, situated about one mile from the river, on the west bank, is a small town, where the inhabitants of the surrounding country purchase their supplies and bring their produce for shipment.

Williamston, the county-seat of Martin County, is situated on the west bank of the river, distant about one mile. It is the largest town on the river, and has a population of about 900. A railroad to Tarborough has been partially constructed, but it is doubtful if it will be completed for a long time. The shipments from Williamston are principally shingles, although some cotton is shipped. Previous to the late war large quantities of tar were manufactured in this vicinity, but this branch is now entirely abandoned. Several lumbermen from the North make this their headquarters, and during the dry season have large quantities of logs cut in the adjacent swamps, which are floated out during freshets and rafted or shipped North, to be manufactured into lumber.

Jamesville, twelve miles above Plymouth, is the initial point of a railroad built by the Jamesville and Washington Lumber Company, extending some eight miles into their swamps. They propose continuing this road to Washington, on the Pamlico River, so as to have two points from which to ship their lumber and shingles. This company have already expended upward of $200,000 on this road, in building their mills, and in other improvements looking to the development of their swamp property, of which they have over 60,000 acres.

From Jamesville to the mouth of the river, fishing is extensively carried on, giving employment during the season to a considerable number of men, and in which much capital is invested.

Plymouth is situated on the west bank of the river, about seven miles from its mouth

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and is its lowest shipping-point. A large trade is done at Plymouth, as the surrounding country for several miles obtains all needed supplies there. Large quantities of shingles are shipped to Norfolk and Baltimore, and some cotton. A considerable portion of the freight to and from Plymouth is carried by the steamer Ella up the Chowan and Blackwater Rivers to Franklin depot on the Seaboard and Roanoke Railroad, and thence to Portsmouth over the railroad.

The Roanoke is subject to freshets, which rise with great rapidity and overflow the banks at many points. These freshets ordinarily rise about 12 to 15 feet at Weldon, and during a rainy season are almost continuous. At other times they only last a few days, after which the river falls almost as rapidly as it had previously risen. Generally twice in each year, spring and autumn, there is a freshet which rises to a height of 25 to 30 feet at Weldon, and occasionally much higher; in 1865 the river rose at Weldon to a height of 50 feet above ordinary low water. The banks are generally of a sandy loam, and are fringed with trees to the water's edge for the greater portion of its length. In the neighborhood of Weldon, and for sixty or seventy miles below, they are from 20 to 50 feet above ordinary low water; farther down they become gradually lower, until, for fifteen or twenty miles above the mouth, they are not more than from 1 to 3 feet above the level of ordinary low water, with few exceptions; one of these exceptions is at Jamesville, where the bank for a short distance on one side of the river is about 30 feet high. At a few places there are outcroppings of rock—at Halifax, Edwards's Ferry, Hill's Ferry, and a short distance below Hamilton—the rock rising precipitously for 30 or 50 feet, and at the latter place, which is known as Fort Branch, having been the site of a fort of that name during the late war, near 100 feet.

The bed of the river, except in a few places where there are rocks, is of sand. Near the banks there is generally an alluvial deposit over the sand.

The Roanoke is navigable from its mouth to Hamilton, a distance of sixty miles, at all stages of water, for vessels of a draught not exceeding 10 feet, which is as much as can be carried through Albemarle Sound.

The great majority of the vessels which navigate the Roanoke come by way of Norfolk through the Albemarle and Chesapeake Canal, where a draught of water of 6 feet is barely obtainable. The Dismal Swamp Canal, which was another means of communication between Norfolk and Albemarle Sound, is not now open for navigation. The obstructions in this portion of the river are enumerated below in inverse order from that in which the survey was prosecuted.

The side-wheel steamer Southfield, 260 feet long, originally a ferry-boat, converted during the war into a river gun-boat, sunk by the ram Albemarle three-fourths of a mile below Plymouth, in 25 feet of water, and near the middle of the river, thus obliging vessels to pass on either side of it, is not dangerous except at night or in thick weather, as there is a channel sufficiently wide for any vessel to pass, but as several of the steamers pass up and down this portion of the river at night, it should be removed. Above this point there is a good channel past Plymouth for a distance of two miles, where the river is obstructed by three rows of piles driven during the war. A portion of them have been removed, but quite a number in the deepest water still remain, and should be taken out, as should also a row of piles across another channel of the river at the mouth of what is known as Middle River, a short distance higher up. The number of piles in both these channels is about three hundred. The channel above remains unobstructed for four miles, to the mouth of Broad Creek, where a number of schooners, said to be seven, loaded with stone, were sunk during the war.

These vessels were sunk in 27 feet water, and extend nearly across the river, the only available channel now being very narrow, and on the opposite side of the river from the original one. The greatest injury, however, likely to result from the presence of these schooners is the formation of a large bar or shoal immediately below them, where there is and has been for many years a small mud-flat, which, so long as the river-current remained unobstructed, did not increase, but is now by deposits of sand extending across the river; these vessels should therefore be removed. An additional reason for their removal is found in the fact that the Broad Creek Fishery, which before these vessels were sunk was considered one of the most valuable on the river, has, since the war, after one or two attempts to use it, been abandoned.

The channel is thence clear to Gray's Fishery, two and a half miles above, where the remains of a sunken battery are met with, consisting of a mass of timber bolted together, in 18 feet water. This obstruction, like the Southfield, is not dangerous in clear weather; but for the same reasons, and also that it is an injury to the fishery, should be removed. The locations of the sunken vessels and of the piles will be found on the map of the river herewith. There are no obstructions between Gray's Fishery to near Jamesville, where there are said to be portions of sunken vessels, a tug-boat, and the wheels of a double-ender gun-boat, which was sunk and has since been broken up near the shore. The place where these are said to be was pointed out to me, a faint ripple being perceptible on the surface of the water, but a careful sounding failed to indicate anything to obstruct navigation. It is possible that there may remain pieces which interfere with the fishery at this point, as the parties who have been engaged

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in that business state that their nets have frequently been caught and torn. From Jamesville to Hamilton the only obstructions are trees which have fallen into the river; of these there are a great number, but the majority of them are too near the banks to interfere in any way with navigation. At some few points are, also, overhanging trees, which, during the freshet, when they are near a landing, sometimes trouble the vessels, but as it is generally only necessary for the parties on board to trim off a few small limbs, they are not considered worthy of particular mention. Of the other trees, only those which project a considerable distance into the river are proposed to be removed. Of these there are, in the portion of the river now under consideration, one hundred and thirty-three, which will be found at distances exceeding 30 feet from the banks, and in some instances have limbs projecting still farther under water. There is also a large tree standing nearly erect in Shad Island Bend, from its shape a very difficult portion of the river to navigate, and in consequence of the presence of this tree made still more so.

From Hamilton the channel is unobstructed to Indian Highland Bar, about two and one-half miles above. This bar consists of loose rocks, varying in size from gravel to pieces of the size of large cobble-stones, which are probably only a covering to still larger pieces. The channel is very narrow and tortuous, and the difficulty of its navigation is increased by a small sand-bar adjoining it. A steamer, having a load-draught of 6½ feet, which generally runs up the river about twenty-five miles above Hamilton, is compelled, during the low stages of water, to stop at that place, through inability to pass over this bar. It is believed that, with a moderate expenditure of money, a sufficient quantity of these loose rocks can be dredged out to permit the passage, at all stages of water, of any steamer plying on the river.

From this bar to Hill's Ferry, a distance of two and one-half miles, are several bars or shoals, which are said at times to interfere with navigation. An examination, however, failed to indicate any necessity for their present improvement. Their position may be found on the map; they are known as Williams's Bar, bar at Appletree Gut, and bar below Taylor's Ferry.

From Hill's Ferry to Clark's Landing, a distance of twelve and one-half miles, there is only one bar which obstructs navigation, known as Clark's Bar, and located near the landing of that name. Owing to a freshet in the river, no examination sufficiently reliable to be the basis of an estimate for its improvement could be made.

Between Clark's Landing and Smith's Landing, a distance of eight miles, and near Norfleet's Ferry, about three-fourths of a mile apart, are two rocky bars, known by the river-pilots as Little Rocky Bar and Big Rocky Bar. From the same cause as at Clark's Bar, no examination of these bars could be made. They are said, by persons well acquainted with the river, to consist of loose rocks, of various sizes, and are presumed to be somewhat similar in character to Indian Highland Bar, before described. One of the best-informed pilots on this portion of the river informed me that the principal obstruction at both these bars is the sand, which, after freshets, is found to have been shifted about and banked up in large masses in their immediate neighborhood. Supposing that these bars are similar to Indian Highland Bar, it is probable that they might be improved in the same way. An examination of them could readily be made at a low stage of water.

There is also a shoal a short distance below Smith's Landing, but when examined it did not seem to need present improvement.

The remaining portion of the river, from Smith's Landing to Weldon, is full of bars and shoals, with some rocks. These shoals consist of sand which is shifted about during each freshet, so that their appearance *now* may be entirely different from that presented at the time the examination of them was made, and although but few of them offered such obstacles to navigation as to require improvement when examined, there may be others since the last freshet which now need it. They will be described in detail, beginning at Weldon:

Between Weldon and a short distance below the old railroad-bridge, a distance of about one mile, are found all the rocks which obstruct navigation, with the exception of a ledge at Halifax. They prevent the steamer Silver Wave coming up to Weldon even when the water is considerably above the lowest stage, and as there is no suitable landing between them and Halifax, freight has to be carried by rail that additional distance, and over a road having no connection with the steamer. This operation increases the charges for freight very materially. These rocks, which are neither numerous nor large, are designated on the maps; those which require removal are numbered in red 2, 3, 4, 9, 11, 12, 13, 14, 15, and 16, and are estimated to contain about 420 cubic yards to the bed of the river, below which it is not considered necessary to remove them. There is also a shoal extending nearly the whole of this distance, which will require the dredging out of 18,000 cubic yards of sand. Immediately below the old bridge is also a shoal which will require dredging to the extent of 16,000 yards.

Between Weldon and Halifax is a shoal, marked No. 1, to improve the channel around which will require the dredging of 30,000 cubic yards of sand.

At Halifax is a ledge of rocks extending two-thirds of the width of the river, com-

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mencing on the Halifax side. Below them there is reported to be a shoal extending for a long distance down, but owing to a freshet in the river neither the rocks nor the shoals could be examined in a sufficiently careful manner to give the basis for any estimate for the improvement of navigation in this vicinity. Some distance below is a shoal, marked on the map A, which is quite extensive, and to improve the channel through or around it will require the dredging of 38,000 cubic yards of sand. Further on will be found a shoal marked B, which is not extensive, and it is estimated that the dredging of 4,000 cubic yards will be sufficient to improve the channel at this place. A short distance below Shell Landing is Looking-glass Bar, commencing at the mouth of a creek of that name, through which the channel is tortuous. To improve this channel will require the dredging of 11,000 cubic yards of sand.

A few miles below Edwards's Ferry is Old Dave's Shoal, which is at times a serious obstacle to navigation. To improve the channel through this shoal will require the dredging of 8,000 cubic yards of sand. These are, it is believed, all the bars which require present improvement.

As between Hamilton and Jamesville, so there are between Hamilton and Weldon a large quantity of trees in the river. Of these it is proposed to remove two hundred and fifty-four, which will be found sufficiently near the channel to be obstacles to navigation.

It is not expected that the dredging out of channels through the shoals above mentioned will be a permanent improvement. Any plan which contemplates this end must provide for the confinement of the water within a limited area during the summer months or when the water is at a low stage, through the numerous bars and shoals which abound in the river for thirty or forty miles below Weldon. This could only be done by an outlay of money seeming to be wholly incommensurate with the interests at present involved.

An estimate is, however, submitted of the cost of constructing dikes or jettees where they are considered necessary to accomplish this object. They will be found laid down on the map in red.

	Running feet
On Sheet No. 1	$59,750
On Sheet No. 2	66,68[illegible]
On Sheet No. 3	25,05[illegible]
On Sheet No. 4	1,5[illegible]
	156,0[illegible]
At $1.50 per foot	$234,0[illegible]

It is proper to remark that the river from Weldon for forty miles down is not now navigable for vessels of a greater draught of water than about 4 feet at an ordinary low stage. The larger class of vessels which come through the sound rarely pass more than a few miles above Hill's Ferry.

I submit herewith an estimate of the cost of the proposed improvements to the navigation of the Roanoke, omitting any mention of those portions which, from the state of the water, could not be properly examined.

The estimates for the improvement of the river from Weldon to Smith's Landing are based upon making a channel 5 feet deep and 60 feet wide at what is, except in extreme cases, the *lowest* stage of water, as far as could be ascertained.

ESTIMATE.

For the removal of 420 cubic yards of rock, near Weldon, at $20	$8,4[illegible]
Dredging channel from Weldon to Old Bridge, 18,000 cubic yards, at 35 cents	6,3[illegible]
Dredging channel below Old Bridge, 15,000 cubic yards, at 35 cents	5,2[illegible]
Dredging channel at Shoal No. 1, 30,000 cubic yards, at 35 cents	10,5[illegible]
Dredging channel at Shoal A, 38,000 cubic yards, at 35 cents	13,3[illegible]
Dredging channel at Shoal B, 4,000 cubic yards, at 35 cents	1,4[illegible]
Dredging channel at Looking-glass Shoal, 11,000 cubic yards, at 35 cents	3,8[illegible]
Dredging channel at Old Dave's Shoal, 8,000 cubic yards, at 35 cents	2,8[illegible]
Dredging channel at Indian Highland Bar, 4,500 cubic yards, at 35 cents	1,5[illegible]
Removal of 254 trees and snags between Weldon and Hamilton, at $10 each	2,5[illegible]
Removal of 133 trees and snags between Hamilton and Jamesville, at $10 each	1,3[illegible]
Removal of 1 tree in Shad Island Bend Removal of steamer Southfield Removal of piles Removal of schooners at Broad Creek Removal of sunken battery at Gray's Fishery	7,5[illegible]
	65,5[illegible]

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Add for contingencies and superintendence 20 per cent..... $13,117

78,702

The river is located in the collection-district of Edenton, North Carolina. The nearest light-house is Roanoke River light.

Very respectfully submitted.

GEO. H. ELLIOTT.

Colonel WM. P. CRAIGHILL,
Corps of Engineers.

CUSTOM-HOUSE, EDENTON, NORTH CAROLINA,
August 7, 1871.

SIR: In compliance with your request, as contained in your letter of 25th instant, I have the honor to submit the following information in regard to the importance to the local and general interests of the country of the further improvement of the Roanoke River:

First. The Roanoke River is situated in the collection-district of Albemarle, North Carolina, above Edenton, the port of entry, which is nearly opposite the mouth of the Roanoke River.

Second. At the port of Edenton for the fiscal year ending June 30, 1871, the revenue collected, from all sources, amounted to $1,018, as shown by the records of this office.

Third. Edenton is the only port of entry for this collection district, but the following ports of delivery are situated on the Roanoke River, viz, Plymouth and Williamston; while freight is shipped from and landed at Jamesville, Hamilton, Hill's Ferry, and other landings on the river.

Fourth. It would be difficult to estimate the exact amount of commerce and navigation and other interests which would be benefited by the further improvement of the river, but referring you to the statistics given in a previous communication on this subject, dated October 14, 1870, I would respectfully state that the advantages of commerce and navigation will be greatly benefited when the projected improvements shall have been completed. The Roanoke River is situated in a very productive and fertile portion of this section of North Carolina, and the improvement of the river will be of great advantage to the commercial interests of an extensive agricultural region. The work already contracted for will remove all the principal obstructions, from the mouth of the river to Williamston, a distance of thirty-eight miles. Above that point are several wrecks and bars; at Willow Bend the river is obstructed by several wrecks; a short distance above Hamilton a propeller is sunk, and also a barge; between Hamilton and Weldon there are two sand-bars or shoals, and a bar, known as Rocky Bar, which is near the lower part of Halifax County. It may be estimated that about one-half of the commerce and navigation of the Roanoke River would be benefited by the removal of obstructions just mentioned; also that there would be a considerable increase of business from the upper part of the Roanoke if these improvements were made. I may add that the removal of the obstructions at several points on the river will greatly facilitate the advantages of navigation, as in many instances the obstructions are of such a nature as at present very materially to affect the safety and convenience of navigation.

The foreign import and export trade of this collection district is small, but the coastwise trade is of considerable importance, as nearly all our products are shipped to the northern markets, and large freights of merchandise are constantly being transported to merchants, planters, and others doing business at various places on the Roanoke River. The counties of Washington, Martin, Halifax, Northampton, and Bertie, are all benefited by the navigation on this river, while the interests of the whole collection-district will be materially improved when the Roanoke is freed from obstructions.

It may be safely computed that the value of products carried out of the section of country bordering on the Roanoke River and its tributaries, will annually amount to over two million dollars, and the amount of merchandise purchased at the North, and brought to that portion of this district, will amount to over one million and a half dollars.

I have endeavored to make a full representation of facts connected with the desired improvement of the Roanoke River, but if I can be of service in furnishing any additional evidence of the importance of this work, it will afford me pleasure to do so.

Very respectfully, your obedient servant,

CHAS. G. MANNING,
Collector.

Brevet Lieutenant-Colonel W. P. CRAIGHILL,
Major of Engineers, U. S. A., Baltimore, Maryland.

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Q 23.

NEUSE RIVER, BELOW GOLDSBOROUGH, NORTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, December 30, 1871.

GENERAL: A survey or examination of the Neuse River below Goldsborough was ordered in the appropriation bill for the improvement of rivers and harbors, approved March 3, 1871. The field-work was executed by Assistant Engineer William Popp, between April 17 and June 17, 1871, with as much care and completeness as was permitted by the extent of the funds available for that purpose. Mr. Popp was then engaged, in connection with other duties, in preparing his report and maps, which are submitted herewith. The maps are seven in number. The details of his operations are given in his report, and need not to be referred to here, except to call attention to them, as well as to their results.

The characteristic features of this river are much the same as those of the Roanoke, mentioned in my report of December 5, 1871. From Goldsborough to New Berne, a distance of about ninety-seven and one-half miles, the river flows through a low, heavily timbered country. The channel is in parts tortuous and obstructed by snags and sunken logs, having a width varying from 80 to 250 feet, with a minimum depth of 4½ feet. Below New Berne it may be considered a broad estuary, and furnishes a sufficient volume of water for the commerce of that place.

Improvements made by the State of North Carolina, previous to the war, consisting of the construction of wing-dams and the removal of snags, have so far ameliorated the condition of the river as far up as Contentnea Creek, thirty-one and one-half miles above New Berne, that, excepting artificial obstructions placed during the war, the section of river now particularly requiring improvement may be considered as being included between Contentnea Creek and Goldsborough, a distance of about sixty-six miles.

Should it be decided by Congress to make an appropriation for the Neuse River, it is recommended that it be limited in the beginning to the amount estimated as needed for the removal of snags, logs, fallen trees, overhanging trees, and artificial obstructions, such as sunken vessels, stone-cribs, &c., $51,000.

Certain cut-offs, proposed by Mr. Popp, may be desirable at a later stage of the improvement of the river, but it is deemed best to defer a decision as to their propriety until more study can be given to the subject than has been thus far possible. The estimated cost of these cut-offs is $100,000.

Attention is called to the condition of the railroad-bridge crossing the river at a point about three miles below Kinston.

A letter of July 31, 1871, from the deputy collector at New Berne is also transmitted.

Respectfully submitted.

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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BALTIMORE, MARYLAND, *October* 14, 1871.

MAJOR: I have the honor to submit the following report on the survey of Neuse River, North Carolina, made under your direction, from April 17 to June 17, 1871.

In pursuance of your orders, I started with my assistant, Mr. Charles Humphreys, on April 17, to Goldsborough and New Berne, North Carolina, and arrived at the latter place April 18. At New Berne I saw several of the gentlemen mentioned in a letter of Hon. J. Dixon, United States Representative form North Carolina at the time of the passage of the act in which provision was made for the "examination or survey of Neuse River, from Goldsborough to its mouth." These gentlemen introduced me to Mr. J. J. Roberson, a gentleman whose familiarity with the river and adjacent country, as well as his former experience in superintending the construction of river-improvements, made him peculiarly competent to furnish me with valuable information. Several days were consumed in making necessary preparations. A "flat" was hired and provided with a shed, intended as quarters for myself and party; provisions were purchased, and two yawl-boats hired. As it was intended to commence the survey at Goldsborough, it was desirable to have the flat and boats brought there with as much dispatch as possible. A contract was therefore made with Edward Brown to "pole" the same to Goldsborough in six days or less, starting immediately after completion of our preparation. Under this contract the party employed seven men, started April 22, and delivered the flat with its contents at Goldsborough Bridge April 28.

Mr. Roberson accompanied me on this trip, pointing out the various points of interest, and describing the operations carried on by the State of North Carolina sixteen years ago. Part of these consisted in erecting wing-dams in various places where the sudden increase of width of the river-bed had caused bars, and these appear in the accompanying map of the river. Snags were extracted, and fallen and leaning trees removed from Contentnea Creek to Pitch Kettle, and this portion of the river is, even to this day, remarkably free of such obstructions.

Beyond the mouth of Contentnea Creek the improvements of the State of North Carolina did not extend, and we will see further on that this portion of the river, viz, from Contentnea Creek to Goldsborough, is the one that especially requires improvement.

The actual survey of the river was commenced April 29. The manner in which it was conducted was the following: One of the yawl-boats, with three oarsmen and all requisite tools, was charged with the duty of erecting stations in advance of the actual surveying party, which followed in the other boat. The stations generally consisted of stiff poles from twelve to fifteen feet long, driven in the sandy bottom of the river, and made distinguishable by paper flags, ("whites.") The stations alternated from one bank of the river to the other in such manner that each three consecutive poles formed a triangle whose obtuse angle was about 120°. All three angles of each triangle were observed with a sextant, the necessary corrections being made immediately after each observation. Wherever the nature of the banks admitted it, short base-lines were measured, whose bearing and length served as a check for the length and bearing to be plotted from the two bases at Goldsborough and New Berne. This method of surveying, although not well adapted for long and narrow strips, had necessarily to be adopted, because the nature of the banks precluded the possibility or at least feasibility of operations on them, in probably three-fourths of their whole length, with the means at our disposal.

After observing the required angles at each station, the sounding-boat was rowed toward the next station, keeping as much as possible on a line with the one just left. Soundings were taken at regular intervals by means of pole and lead-line. The obstructions occurring in the river were examined and counted as well as was practicable. The topography of the river-banks, as far as it could be seen, was sketched. A tidal record was kept at New Berne during the progress of the examination. A movable tide-gauge was driven in the vicinity of the flat, and readings taken on it three times a day, and whenever the flat moved. As mean summer stand of river was assumed that of May 1, all indications and opinions of persons familiar with the river pointing to this result.

Shortly after leaving Goldsborough severe rains caused a freshet on the river, which rose to 6½ feet above the assumed plane of reference, and did not entirely pass away until the latter part of May. Besides retarding the progress of the survey somewhat, this freshet covered most of the snags and fallen trees, which at an ordinary stage of the river are obstructions, but which now, hidden from our sight, escaped observation. Whitehall (on maps Jericho) was reached May 11, Kinston, May 21, New Berne, June 6.

The portion of the Neuse from New Berne to its mouth having been surveyed as late as 1868, by Coast-Survey parties, and there being no special complaint of bars, &c., made by shippers, I concluded to restrict myself to a mere examination of this portion, stopping and surveying only the obstructions placed there during the rebellion.

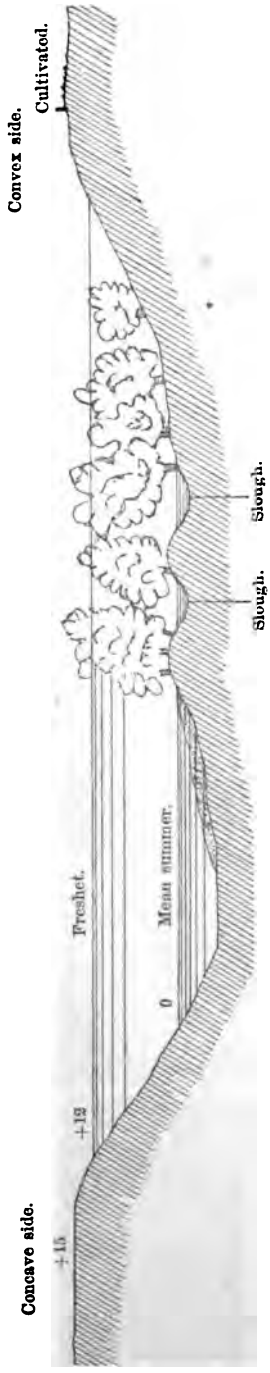
After this examination was completed, and in pursuance of orders received from you, I disposed of the engineer property in my charge at public sale, and returned June 17.

The results of this survey were plotted in the office from June 17 to October 14.

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About 1,500 triangles were plotted by means of calculated distances, the balance by angles.

DESCRIPTION OF THE NEUSE RIVER.



The Neuse River, as far as it comes into consideration in this report, flows through the counties of Wayne, Lenoir, and Craven, North Carolina, in a generally easterly direction. The distances by water, as found by the recent survey, are—

From Goldsborough to Whitehall, 22 miles.
From Whitehall to Kinston, 24¼ miles.
From Kinston to Contentnea Creek, 19 miles.
From Contentnea Creek to Pitch Kettle, 10⅜ miles.
From Pitch Kettle to New Berne, 21 miles.

From Goldsborough to New Berne the river is narrow, and navigated at present only by small boats, rafts, and flats. From New Berne to its mouth it is a wide estuary, and navigable for sea-going vessels drawing not over nine feet. The velocity of flow for the section from Goldsborough to Pitch Kettle is from 1½ to 2 feet per second. Below Pitch Kettle it is very small, and greatly influenced by prevailing winds. There is no appreciable tidal rise and fall at New Berne, the prevailing winds seeming to govern the indications of the gauge.

The character of the country through which the river flows is that of alluvial land; it consists chiefly of clay, sand, and shells. A little below Broadway Landing a fine-grained slate is denuded by the river, and at Fort Barnwell a conglomerate of shells of considerable toughness. With these two exceptions the bed of the river consists entirely of coarse sand and gravel.

The elevation of the banks varies from about 80 feet (at Limestone Fishery) to a few inches above mean summer stand. From Goldsborough to the mouth of Contentnea Creek the height is generally from 10 to 20 feet on the concave side, and from 3 to 6 feet on the convex side; from Contentnea Creek to New Berne it seldom exceeds 5 feet, and is very generally only a few inches above mean summer stand, (0.) The only range of hills which the river touches is the one running from Whitehall in an almost due westerly direction. A feature of the river are the numerous sloughs, which branch off from it at an elevation of a few feet above zero, and sometimes run parallel with the river for considerable distances. After the subsidence of freshets stagnant water remains in the deeper portions of these sloughs, thus rendering the vicinity of the river anything but healthy. The subjoined sketch presents a general cross-section for this portion of the river. It will be seen from it that a belt of low land, densely wooded, borders the convex side of the river, which forms part of the bed for freshet discharge. In straight reaches and in the "Let Lones" a belt of low land borders the river on both sides.

The course of the river, from a point about nine and a half miles below Goldsborough to the mouth of Contentnea Creek, is very tortuous and difficult for navigation. A remarkable series of bends occurs between stations 148 and 215. The river contracts here suddenly to a width of about 80 feet, and, after making several abrupt bends, enters a straight reach, in which it spreads suddenly to a width of 250 feet.

Another series of abrupt bends occurs about four miles below Whitehall; and still another, the most formidable to navigators, begins about seven and a quarter miles above Kinston, and continues for five miles. This latter series is vulgarly called "Let Lones," and is much dreaded by the flat-boatmen navigating the river. In all these bends the bed of the river is very much contracted, the depth of the channel is increased, as is also the velocity of flow on the current side, while the convex side shows eddies and back currents. To aggravate the evil all floating logs, &c., are

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readily deposited in these bends, and, occupying the concave side of the river, choke up the channel completely. The regimen of the river in those places is, of course, very unstable. New cut-offs are continually forming, as will be seen on glancing at Sheet III of the accompanying map of the river. Many years, however, must elapse before a new cut can be made practicable by the action of nature alone, because the low land bordering on the river is generally so densely wooded that the intermingling roots of the larger trees, such as cypress, gum, &c., of which the growth consists, form an almost compact, and certainly a very strong and lasting wall, against which the action of water is nearly ineffectual. The removal of those trees, with their roots, would, in most cases, induce the speedy formation of new cut-offs.

The governing depth of water in the channel from Goldsborough to Kinston is 4½ feet; below Kinston 5 feet. The minimum depth of 4½ feet is found on two bars, one about one and a half miles above, the other about half a mile below Kinston.

About three miles below Kinston the North Carolina and Atlantic Railroad crosses the river on a pile-bridge, at an angle of 75° to the direction of the current. The clear width of span is 17 feet 6 inches; the clear height or reference above zero of the floor is 17 feet. From these dimensions it is apparent that the bridge is an obstruction to navigation. The original bridge, which was burned during the rebellion, was a "Howe truss" of two spans, one of them being a draw.

The principal obstructions to navigation besides those mentioned are snags and fallen trees. They consist, in a great part, of cypress and gum trees, which range from 6 inches to 5 feet in diameter. The majority of them, however, are from 2 to 2½ feet in diameter. There are also many hanging trees.

About seven miles below Kinston there is an artificial obstruction, the Southwest Blockade, which almost completely blocks the river. It consists of five cribs filled with stones and placed in two lines, checkerwise, across the river.

Of all the county bridges which crossed the Neuse between Goldsborough and New Berne none are standing at present, except the bridge at Kinston. The charred remains of the others form obstructions in the river.

The portion of the river from the mouth of Contentnea Creek to Pitch Kettle was, as already mentioned, improved by the State of North Carolina in the years 1856 and 1857. The improvements consisted in the removal of snags and the erection of wing-dams. I had been informed at New Berne that surveys had been made of the river before the construction of the dams, and that maps and records were on file at Raleigh; but upon direct inquiry, addressed to the honorable secretary of state of North Carolina, was informed that no records were on file relating to the survey or dams.

The wing-dams leave the shore-line at an angle of from 12° to 26°, until they reach a point at a sufficient distance from the bank to reduce the width of the river to the desired dimension, when they run parallel with the banks.

The diagonal or wing portion of these dams consisted of a double row of piles and sheet-piling, filled with muck taken from the banks, and floored over. Width of dam 6 feet. The parallel part of the dam consisted of alternate stretches of the above solid dam and sheet-piling alone. So far as I could judge without having previous surveys at my disposal, the effect of the dams was satisfactory. They are mostly well preserved.

Immediately below Contentnea Creek there are the remains of a coffer-dam, destined to inclose the foundations of a partial lock, but which was wrecked when the water was pumped out preparatory to laying the foundations. The lock was intended to effect a rise of two feet at the mouth of Contentnea Creek. The remains now form a very disagreeable obstruction.

At Pitch Kettle Landing the river makes a very sudden bend, much dreaded by flat-boatmen on account of the violence of the current in the narrow part, and the great depth of water, precluding the use of their poles.

From Pitch Kettle to New Berne the river is tolerably free of snags, and there are no obstructions, except the "Blockade" above New Berne.

The blockade is about three miles above New Berne and closes three principal channels through which the ascent of the river may be continued, viz, Bachelor's Creek Channel, Neuse River or Main Channel, and Lingfield Channel.

Bachelor's Creek Blockade consists of the following obstructions: On the right bank there are four triangular cribs filled with stone, and secured by piles driven at the corners. On the left bank there is a barge, 136 by 32 feet, filled with stone and surrounded by piles. The middle of the channel, 150 feet wide, is open, with the exception of a small spot in which there is only 4½ feet of water, and which is probably the top of a pile of rocks.

The Bachelor Creek Channel connects about one and a half miles above the blockade, through a thoroughfare, with the Neuse; the governing depth of it is 6 feet.

The blockade of the main channel consists of the following obstructions, starting from Hog's Island:

1. Ten triangular cribs, of 10 feet on a side, filled with stones, and secured with piles.

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2. Schooner Snowsquall, 60 feet by 15, filled with stone, and with 6 feet of water on her deck.
3. Schooner, name unknown, 44 feet by 12, with from 6 to 9 feet of water on her deck.
4. Interval of 25 feet occupied by a few piles.
5. Canal-boat, 35 feet by 8; 4 feet of water on her deck.
6. Interval of 19 feet, with some piles.
7. Schooner, unknown, 48 feet by 13, partly dry.
8. Opening, 100 feet wide, now used by flats.
9. Six triangular cribs, reaching to Green Island.

The main branch of Lingfield Channel is blockaded in the following manner, commencing on the right bank:

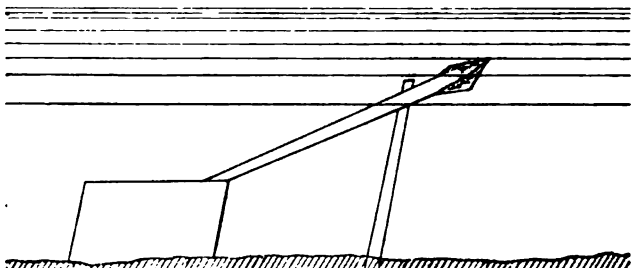
1. Sixteen triangular cribs, of the same dimensions as those in main channel.
2. Opening of 100 feet.
3. Schooner Elizabeth, 60 feet by 20, and 12 feet of water on her bow; her stern dry.
4. Interval of 40 feet.
5. Brig, name unknown, 85 by 30, partly dry.
6. Six triangular cribs.

At Fort Point, about four miles below New Berne, there is another, the "Fort Point Blockade," which, commencing at the right bank, consists of the following obstructions and free intervals:

1. A number of piles in not over 7 feet of water.
2. Opening 1,500 feet, with from 7 to 11 feet of water, a portion of the Swash Channel, and at present the only one used.
3. Brig, name unknown, 101 feet by 40; 3 feet of water on her deck.
4. Interval of 60 feet.
5. Schooner Isaac W. Hughes, 83 feet by 25; 5 feet of water on deck.
6. Interval of 300 feet.
7. Schooner Sea Witch, 80 feet by 28 by 8½; from 4 to 5 feet of water on her deck.
8. Interval of 600 feet.
9. Schooner W. S. Robbins, 80 feet by 28.
10. Interval 750 feet.
11. Schooner Angelina, 60 by 15 feet.
12. Opening 300 feet.
13. Schooner Lorena, 40 by 12 feet.
14. Interval 50 feet.
15. Schooner Nautilus, 50 by 15 feet.
16. Thirty-nine piles, reaching to left bank.

All the hulls of vessels contained in this blockade, as well as that above New Berne, are much broken up and entirely worthless.

A short distance below the line of sunken hulls there is a double line, checkerwise, of "Yankee-catchers." These "Yankee-catchers" consist each of three iron-shod piles, firmly connected together at their butt-ends and secured to a box, which is filled with stones and serves as an anchor. The piles slant under an angle of about 20° to 30° with



the horizontal line; their points are at various depths below the water's surface. Small piles driven perpendicularly in the ground, and connected with the slanting piles by means of spikes, support the whole frame in its position. These "Yankee-catchers" form a dangerous obstruction for sailing-vessels, as they are lying in the track of tacking vessels, and are not visible.

A short distance farther down stream there is another line of "Yankee-catchers," which closes the eastern channel at the upper end of the Middle Ground; eleven sets were found here in from 6 to 8 feet of water.

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Many creeks empty into the Neuse, some of which are of importance. In the section below Goldsborough the Contentnea is by far the most important, the greater portion of the trade which is now being carried on the river coming from this creek. I was informed that a bar in this creek, not more than two miles above its mouth, impeded navigation greatly, but as my instructions did not include any tributary of the Neuse, I did not feel authorized to examine it.

Although there are some bars below New Berne, it was deemed unnecessary to examine them, because it was well established by the testimony of all masters of vessels and pilots that the governing bar for vessels navigating the Neuse is not in the river, but at Hatteras Inlet. The water-draught which can be taken over this bar is 9 feet at high water.

STATISTICS.

The country through which the Neuse flows directly, and that which is drained by its tributaries, is still in a state of great prostration from the effects of the war of the rebellion.

The principal staple of this portion of North Carolina is cotton. Corn, wheat, potatoes, and a few vegetables are also raised.

Another important resource of the country consists in their pine forests, which yield excellent pitch, turpentine, and rosin. Extensive cypress-swamps occur in the immediate vicinity of the river, which are being worked by some shingle-factories. Valuable timber of other descriptions, especially oaks of various species, (white, red, and post oak,) beech, ash, &c., is growing along the banks of the river, but is at present not made useful to any extent.

Goldsborough is a new town, and an important railroad station. The Weldon and Wilmington and the North Carolina and Atlantic Railroads cross here. The town was transferred to this place from Old Waynesborough, on the Neuse, not many years ago. The population amounts to probably 1,500 inhabitants, about one-half of whom are colored. A great deal of cotton is sent to Goldsborough from the neighboring plantations, within a considerable distance, and shipped to the North on the Weldon and Wilmington Railroad. There is at present no trade whatever carried on by Goldsborough on the Neuse; but during my presence at the place a reconnoitering party was sent out by the Weldon and Wilmington Railroad for the purpose of ascertaining the practicability of navigating the river by means of a light-draught steamboat. I ascertained afterward in Goldsborough that the company had purchased a steamer, but did not intend running her until the river was improved.

Whitehall is a small settlement, almost in the middle of dense pine forests, which furnish a great supply of rosin, turpentine, &c.

Kinston is a thriving town of about 1,000 inhabitants. Cotton is raised in the vicinity of the town to the exclusion of everything else. There is a steam saw-mill here, the only one I noticed on the river.

New Berne is situated on the confluence of the Neuse and Trenton Rivers, in a rather low country. The population is estimated at 3,000, the colored people being decidedly in the majority. A glance at a good general map will show the great advantages of the geographical location of New Berne. Lying as it does at the confluence of two considerable rivers, and crossed by an important railroad, it is the natural entrepot for all the back country drained by the Neuse and Trenton Rivers and their tributaries. The trade in cotton, naval stores, and shingles, is very considerable. Appendix A, containing a statistical statement kindly furnished by United States Special Deputy Collector E. N. Hubbs, shows the various items of which the exports of the port consisted.

The mode of navigation pursued before the rebellion was the following: A light-draught steamer towed a number of flats up the river, and left them at their respective places of destination to take in their freight and make their down-stream trip alone. At present this navigation is impossible, and the country drained by the Neuse and its tributaries is to a great extent compelled to send their staple overland to the nearest railroad. The high rates of freight charged by these latter is a very serious drawback on the cultivation of cotton, especially as the climate and soil of North Carolina are not well adapted to it, and therefore a very small margin of profit remains to the cultivator.

PROPOSED IMPROVEMENTS.

It appears that the depth of water below New Berne is sufficient, and could not be increased to any advantage without permanently improving the bar at Hatteras Inlet. Above New Berne the governing depth is 4½ feet, and this seems also to be sufficient for the purposes of the proposed mode of navigation. The only improvements deemed necessary, consist, therefore, in the removal of snags, logs, fallen trees, hanging trees, the straightening of bends which are too abrupt to be navigated, and the raising of artificial obstructions, such as cribs filled with stone, piles, and hulls of vessels.

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PROPOSED CUTS.

No. 1. Between stations 148 and 215, cut 50 feet wide at water's surface, 5 feet deep, slopes 1 to 1, cubic yards	75,000
No. 2. Between stations 795 and 920, same dimensions as above, cubic yards	143,500
Total	218,500

At 40 cents per cubic yard, $87,400.

Deflecting-dikes at entrance of each cut, built in the same manner as those built formerly by the State, 2,000 linear feet, at $4	$8,000
Removal of snags, fallen trees, &c., 5,000 snags, at $7	35,000
This includes the bends proposed to be cut off; if they are cut off as proposed, the number of snags reduced to 4,000, at $7	28,000
Removal of entire blockade below Kinston, 116½ yards of rubble-stones and crib-frames, at $4	465
Removal of a portion of the blockade at Hog Island, to give a channel 150 feet wide and 6 feet deep	900
Removal of 1 brig and 2 schooners from Fort Point Blockade, and of all "Yankee-catchers" immediately below it	5,000
Removal of "Yankee-catchers," closing eastern channel at Middle Ground	100
Removal of piles of burned bridges, and of coffer-dam below Contentnea Creek	1,200
For engineering superintendence	5,000
Add 10 per cent. for contingencies	13,950
Total	153,150

If the two proposed cuts be not made, the cost will be reduced thus:

Snags, fallen trees, &c	$35,000
Southwest Blockade	900
Hog Island Blockade	300
Fort Point Blockade	5,000
"Yankee-catchers,"	100
Piles of bridges and coffer-dam at Contentnea Creek	1,200
Engineering superintendence	2,500
Add 10 per cent	4,500
Total	50,400

In relation to the information called for by circular of June 10, 1868, paragraph 2, I have to report the following:

1. Answered in body of report.
2. Cannot be answered concisely. The river can be improved to a very great extent if sufficient funds be appropriated.
3. About $50,000 can be profitably expended during the next fiscal year.
4. Work is located in Pamlico collection-district.
5. Nearest port of entry is New Berne, North Carolina.
6. Revenue collected during the year, $5,700.
7. Commerce benefited may be judged by the number of vessels arrived and cleared, which was 325, and the fact that all the country drained by the Neuse and its tributaries is concerned.
8. No proposals received.

All of which is respectfully submitted.

WILLIAM POPP,
Assistant Engineer

Major WM. P. CRAIGHILL,
Corps of Engineers, U. S. A., Baltimore, Maryland.

PORT OF NEW BERNE.

Exports to foreign countries during the fiscal year ended June 30, 1871.

Lumber, feet	500,000
Shingles	500,000
Tar, barrels	2,000

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Spirits turpentine, gallons	800
Staves	80,000
Shooks, (box)	10,000
Railroad-ties	5,000

The above figures are nearly exact. Some small exports, not worth mentioning, were made with them, such as lard, peas, &c.

E. HUBB.

NEW BERNE, NORTH CAROLINA, *July* 31, 1871.

PORT OF NEW BERNE.

Shipments coastwise to domestic ports during the fiscal year ended June 30, 1870.

Lumber, feet	5,000,000
Cotton, bales, (400 pounds)	20,000
Spirits turpentine, gallons	400,000
Crude turpentine, barrels	500
Tar, barrels	2,000
Pitch, barrels	2,000
Corn, bushels	500,000
Staves	100,000
Shingles	5,000,000
Potatoes, (sweet and Irish,) barrels	2,000
Hides, (dry and green,) pounds	50,000
Fruit, (green,) barrels	500
Fruit, (dry,) barrels	500
Wood, manufactures of, dozen pails	500
Wood, cords	500
Rosin, barrels	80,000
Railroad-ties	20,000
Vegetables, barrels	200

The above figures were made from a carefully prepared list, and by inquiry from reliable parties, and approximate very closely to the principal articles in amount. Small shipments have been made from the Lower Neuse, which I cannot give figures upon.

E. HUBB,
Deputy Collector.

NEW BERNE, NORTH CAROLINA, *July* 31, 1871.

CUSTOM-HOUSE, NEW BERNE, NORTH CAROLINA,
July 31, 1871.

DEAR SIR: I hand you herewith a statement which is reliable, in round numbers, being rather under than over. I would state that the Neuse River is the great highway of travel from a large section of country on Albemarle and Pamlico Sounds, and it is fair to state that probably 1,000,000 bushels of corn were brought to this port in 1870 by small craft, 500,000 bushels of which, or thereabout, were shipped by rail inland to the tobacco-growing region of the State. Please excuse the delay in sending report, as I have been and still am quite unwell.

Very respectfully, yours, to command,

E. HUBB.

Major WM. P. CRAIGHILL, U. S. A.,
Corps of Engineers, Baltimore, Maryland.

Q 24.

CAPE FEAR AND DEEP RIVERS.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, June 1, 1872.

GENERAL: A survey of the Cape Fear and Deep Rivers, as high as La Grange, was ordered in the appropriation bill of March 3, 1871. The

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work was taken in hand by Mr. George H. Elliott as soon after the passage of the law as the necessary arrangements could be made. His report, dated May 23, 1872, is presented herewith, accompanied by a map of the rivers in twenty-one sheets. Mr. E.'s examination extended as far down as Federal Point. The remaining portion of the lower river, including the bars and channels from the sea, have been lately resurveyed by a party detailed, at my request, from the office of the United States Coast-Survey. Considerable sums of money have been spent by the United States in the improvement of the Cape Fear River below Wilmington. The subject is now being considered by a board of engineers, from whom a report may soon be expected.

The improvement of Cape Fear River above Wilmington, and of its tributaries, would doubtless develop highly important sources of wealth and revenue, of interest in a national point of view, as set forth by Mr. Elliott in his report, and by others referred to by him.

This improvement would, however, obviously be very expensive, and under the circumstances of the case I refrain from making any recommendations for appropriations. Mr. E.'s estimates must be considered as only approximate. It could not be otherwise with the limited means at his disposal for the examination of so long a stretch of country. They indicate the certainty that a permanent improvement of that portion of the river would be very costly, and should only be entered upon after minute and thorough surveys in detail.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, May 23, 1872.

COLONEL: In compliance with your instructions, I have the honor to submit a report on the survey of Cape Fear and Deep Rivers, North Carolina, made under your directions from May 22 to September 30, 1871.

After organizing the party, I proceeded to La Grange, or Carbonton, in Chatham County, the initial point of the survey on Deep River, and followed the course of that stream to Haywood, where it joins the Haw River, and forms with it the Cape Fear: the survey was continued thence along the course of this stream to Reeves's Point, some twenty miles below Wilmington, and nearly opposite to Federal Point.

With slight exceptions, the weather was favorable to the prosecution of the survey, as was also the state of the river, after the first few weeks, low water prevailing throughout the whole extent of that portion of the river where navigation is subject to interruption from that cause. A good opportunity was thus afforded for examining the sand-shoals and bars, which are so numerous in one portion of the Cape Fear, and which, while the survey was in progress, to a very considerable extent suspended navigation for about two months.

The entire country drained by the Deep River comprises an area of one thousand square miles, affording an abundant supply of water for a slackwater navigation, and for mill purposes. It is subject to extensive freshets, which overflow the banks of the lower portion, at times, to a depth of 10 or 12 feet, doing much injury to the crops and farms in the immediate vicinity of the river. The portion of the Deep River country which came within the scope of the survey contains some fine farms, yielding a surplus of grain, which is manufactured into flour and transported to Fayetteville or Raleigh.

The principal claim of this country to notice, however, is its wealth in minerals, particularly in coal and iron, which are very abundant, but, owing to a want of transportation, the mines have, up to the present time, remained almost entirely undeveloped. The extent of the coal-fields has been accurately defined by Professor E. Emmons, in a geological survey made under authority of the State of North Carolina.

In his report of 1852, he estimates them to cover an area of ninety square miles, and to

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contain, at the very lowest estimate, 258,000,000 tons easily workable. The coal is bituminous in character, and has been proved by analysis and actual trial to be of superior quality. Previous to 1850 a shaft was excavated at Egypt to a depth of 460 feet, and a considerable quantity of coal taken out, but the proprietors having no means of getting it to market were compelled to suspend operations. By the recent completion of the Chatham Railroad from Raleigh, there is now continuous railroad communication between Egypt and the sea-board at Norfolk, and the company who own the shaft have made preparations to resume operations, but it is doubtful whether the high rates of freight on the railroad will admit of the mine being worked profitably.

The principal deposit of iron-ore is found about nine miles from the Gulf, in a hill known as Ore Knob, which is elevated some 300 feet above the surrounding country, and covers about 300 acres. A massive vein of valuable ore appears to bisect it. Valuable seams of black band ore are also found, accompanying the coal-seams. Nine miles below Haywood, at Buckhorn, on the east bank of the Cape Fear, is a large ore-hill, covering some 300 acres, which is said to contain a solid vein of nearly pure peroxide of iron, 8 feet in width.

In this vicinity granite is found in considerable quantities, of a quality similar to that used in the construction of the capitol at Raleigh. On the Deep River, below Egypt, is a copper mine, which has been worked for several years, and now yields a valuable ore. In addition to these minerals, there are, some ten miles above La Grangé, extensive deposits of soap-stone, and, throughout the coal-seams, beds of conglomerate from 2 to 3 feet in thickness are found, which, being free from interstratified matter, are well adapted for millstones for grinding corn. There is no timber suitable for naval purposes, but there is, and with judicious cutting long will be, an abundant source of charcoal for use in the manufacture of iron.

The Cape Fear flows in a southerly course for some forty miles; its general direction thence is south and southwest to Fayetteville, whence it again flows southeasterly to Wilmington, and then south to the ocean. In addition to the waters of the Deep and Haw Rivers it receives those of several other streams, and drains a considerable area of country. It is subject to freshets, which overflow the banks and injure the crops and farms adjacent, at times very materially. For the first thirty miles, where the river is wide and the banks generally low, the rise does not exceed 20 feet, but in the succeeding seventy-five miles, where the river is narrow and the banks high, it is much greater, being occasionally at Fayetteville 65 feet. In the country adjacent to the river, for thirty miles, no manufactures are carried on, the attention of the population, which is very thin, being confined to agriculture; some cotton is produced. The next seventy-five miles comprise the yellow-pine timber country, which is dotted over with turpentine-distilleries, the production of naval stores being very large. Large quantities of timber are cut and rafted down the river during freshets to Wilmington. From 3,000 to 5,000 bales of cotton are annually raised, and shipped from Fayetteville, in addition to which a considerable quantity is used by several mills in that vicinity. In the swamps on the peninsula, on the east side of the Cape Fear, a large number of shingles and staves are made and shipped down to the river. The remaining portion of the country adjacent to the river, until near Wilmington, is not much cultivated, consisting, as it does, to a great extent, of swamps, which, however, are not much worked. Above and below Wilmington, for some miles, the swamps have been cleared and ditched, at great expense, for the cultivation of rice, but the majority of these plantations have not yet recovered from the injuries the dikes sustained, principally through neglect, during the war.

The attention of the public men of the State of North Carolina has been long called to the mineral resources of the Deep River country, and that adjacent to the upper Cape Fear. On April 13, 1858, the Senate of the United States, by resolution, authorized and instructed the Secretary of the Navy to cause a thorough examination to be made of the iron, coal, and timber of the Deep River country in the State of North Carolina, and that he report upon the expediency of establishing at some point in that State machine-shops and workshops for the construction of engines, boilers, and naval vessels.

This duty was committed by the honorable Secretary to Admiral (then Captain) Charles Wilkes, who was accompanied by Chief Engineers Hunt and Martin, and Naval Constructor Pook. The report of Captain Wilkes on the subject is full and exhaustive, and was published in Ex. Doc. No. 26, Senate, second session Thirty-fifth Congress, to which, for detailed information, analyses of coal, iron, &c., reference is requested.

Several attempts have been made, at different times, to improve the navigation of these rivers, and thus afford an outlet for the mineral wealth of the country, but so far without success.

A brief sketch of these is here submitted. In 1796 the Cape Fear Navigation Company was chartered by the State of North Carolina, with a capital of $80,000, to improve the navigation of the Cape Fear, and of Deep and Haw Rivers. In 1815 additional privileges were granted to this company, and authority given to increase the capital

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stock to $100,000. In 1823 the legislature authorized the board of internal improvements of North Carolina to subscribe $25,000 to the stock of the Cape Fear Navigation Company on behalf of the State, on condition that said board should have the exclusive direction of the work, making of contracts, &c. I have been unable to obtain any records of what was done under these charters, other than what is contained in the report of Mr. Hamilton Fulton, State engineer of the board of public works for the year 1822, (a copy herewith,) from which it appears that the companies had spent their money, and accomplished no useful result. From this time nothing seems to have been done until 1848–'49, when a company was organized with a capital of $200,000, of which the State subscribed $80,000. Surveys were made of the rivers from Evan's Bridge (now La Grange) to Fayetteville, with a view of constructing locks and dams to maintain a continuous slackwater navigation between the Deep River coal-fields and Fayetteville. Estimates were made and contracts entered into for the completion of the whole work by January, 1852.

During its progress it was found necessary to construct additional locks and dams, thus increasing the cost. As the time approached for the completion of the contract, it was evident that the contractors were unable to fulfill its terms. After some delay they were notified that it was abandoned, and that the company intended to prosecute the work by other agencies, which they did for several months.

During the year 1852 they memorialized the general assembly to have their capital stock increased to $350,000, and that the State's subscription to the same be increased to three-fifths of the whole amount. The request was granted, the work again prosecuted, and was eventually so far successful that a steamer did pass over the whole route, but the company were never able to keep the locks and dams in a condition requisite to secure uninterrupted communication.

Of the causes to which the failure of this attempt to improve the navigation of these rivers may be attributed, it is difficult at this time to speak. Some of the sites for dams were entirely unsuitable, as it was almost impossible to secure the ends from the action of the freshets, except at enormous expense, and the result was the water cut away the banks at the ends of the dams, and so destroyed the utility of the whole work.

Captain Wilkes, in his report, speaks of "the liberal appropriations of the State, so lavishly squandered in the construction of inefficient dams and insecure locks, which were found inadequate to bear their own weight, without the force of the water." Mr. Fulton, in his report, (1822,) says, "It was considered expedient by the directors to commence operations at both ends of the undertaking. The impolicy of this measure has been clearly proved by their expending a great part of their funds without effecting anything of utility." The company who commenced in 1849, instead of profiting by former experience, pursued the same course. The whole work was put under contract at once, and they endeavored to have it all carried on at once. It was found impossible to obtain the necessary hands to work advantageously and secure the work as it progressed, and in consequence a whole season's labor on the locks and dams would be utterly destroyed by the first freshet. Whatever the causes, the work practically was an utter failure, as is readily seen in the present condition of nearly all the locks and dams that still exist. The result has been to shake the faith of the people who contributed their means to this undertaking in the possibility of any future attempt of the kind being successful. The total amount expended by the last company was about $350,000.

The works projected and constructed by these companies consisted of 19 river-dams, from 200 to 1,200 feet in length; 2 slough-dams; 3 short canals; 20 lift-locks, and 3 guard-locks, the location of which may be seen by reference to the map herewith. The dams were built to such a height as to give a depth of 3½ feet on the miter-sill of the lock above. The lock-chambers were 115 feet long by 18 feet wide, except the three nearest Fayetteville, which, to accommodate the lumber interest, were made 115 by 24 feet. The locks and dams were, with two exceptions, constructed of timber cribwork, bolted to the rock, and filled with stone. One of the exceptions noted is the dam at La Grange, which was apparently only temporary in its character, consisting of frame-timber knees fastened to the rock and covered with plank; this dam is kept in moderate repair by the owner of the adjacent mill. The other exception is the lift-lock at Lockville, which is entirely of stone. The only dams on the Deep River which are now intact are at the Gulf, Gorgas, and Lockville; the one below Egypt is not much broken; Rives's is also susceptible of repair, but the location should be changed, if possible. On the Cape Fear, the main dam at Buckhorn is the only one in a moderate state of preservation, the remainder being utter wrecks.

TOWNS ON THE RIVERS.

On the Deep River there are no towns worthy of the name. At La Grange dam there is a grist mill; at the Gulf there are a grist and carding mill and several stores. Preparations were made here during the war to erect extensive iron-works, the ore to be obtained

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from "Ore Knob." A large smelting-furnace and extensive workshops were partially erected, but not completed. Egypt, twelve and a half miles below, is one of the most important places on the river. It is the terminus of the Western Railroad, distant from Fayetteville forty-two miles; it is in the center of the coal-fields, and a shaft has been excavated to a depth of 40 feet, from which coal is now being taken out. Two miles below Egypt are the Endor iron-works, built by the confederate government during the late war; they are quite extensive, and the buildings, furnaces, engines, and other machinery are apparently in good condition. Since the war no operations have been carried on, but I was informed that some gentlemen are now negotiating for the purchase. The great obstacle is the want of transportation, as it would be necessary for them to improve the navigation of the river to bring ore and carry away their products, in order to work to advantage. At Gorgas Dam, twenty-two miles below, is a grist-mill. At Lockville a small population has been gathered by a grist-mill, repair-shops, and the Chatham Railroad, which passes through. The fall in the river in this vicinity, being some 25 feet in a very short distance, affords a very fine water-power, and the company who are negotiating for the purchase of Endor works propose, if they succeed in their operations, to establish at Lockville extensive workshops. Haywood, situated about one mile from Deep River, near its confluence with the Haw, has only a very small population, although the oldest town on the river; the Chatham Railroad passes by it also.

The first town on the Cape Fear, in descending, is Lillington, the capital of Harnett County, distant from Haywood twenty and a half miles. It contains, in addition to the court-house and jail, four stores and a few residences, but having only recently been made the county-seat, has only a small population. The next town is Averysborough, in Cumberland County, eleven and a half miles below, which has a population of from 200 to 300 persons. In this neighborhood turpentine-distilleries are first met with. Large quantities of timber are also cut, to be rafted down the river during freshets. Between Averysborough and Fayetteville there are no towns. Fayetteville, the county-seat of Cumberland County, is pleasantly situated on Rockfish and Cross Creeks, about one mile from the river, and elevated above it some 75 feet. It has a population of from 5,000 to 6,000, and is, next to Wilmington, the principal depot for naval stores in the State. There are numerous turpentine-distilleries in its immediate vicinity, and for miles around it, the products of which are brought here for shipment. A considerable business is also done in flour and cotton. There are several grist-mills and cotton-mills in the vicinity, and this latter branch of business is rapidly increasing. Six steamers are regularly engaged, plying between Fayetteville and Wilmington, two generally leaving each end of the route every week-day. The trip occupies from twelve to fifteen hours during the season when there is an ample depth of water. None of these steamers have a draught exceeding 36 inches, when loaded, and generally only about 28 inches. There was a very fine United States arsenal located here, but it was destroyed near the end of the war, when the whole town suffered much; its business and population have, however, steadily increased since the war. The Western Railroad, before mentioned, runs from Fayetteville to Egypt, through generally an unproductive section of country, agriculturally, but the naval stores furnish ample freights. By the recent extension of the Chatham Railroad to a point on the Western Railroad, Fayetteville has now continuous railroad communication with the sea-board at Norfolk, via Raleigh and Weldon.

Such statistics concerning the trade of Fayetteville as could be obtained are herewith submitted.

STATISTICS—FAYETTEVILLE.

Number of barrels rosin shipped annually	250,000
Number of barrels spirits turpentine annually	40,000
Number of bales cotton annually	3,000 to 5,000
Number of bags flour annually	15,000
Miscellaneous freight, tons	40,000

Elizabeth, the county-seat of Bladen County, is situated near the river, forty-one miles below Fayetteville. A small population is scattered in its neighborhood, engaged in the manufacture of naval stores. There are several stores, supplying the surrounding country, and purchasing its products, which are shipped down the river.

Whitehall, sixty miles below Fayetteville, is a small settlement on the bank of the river, where naval stores are manufactured, and the inhabitants of the back country purchase their supplies and bring their products for shipment. Between this place and Wilmington there are no towns. Landings throughout the whole course of the river below Fayetteville are very numerous, at most of which, for sixty or seventy miles, one or more turpentine-distilleries are found.

Wilmington is situated principally on the east bank of the river, about twenty-five miles from its mouth, and is the largest city in the State, having a population of 15,000. A report on the trade and resources of Wilmington has recently been published by order of the Chamber of Commerce of that city, (copy herewith,) to which refer-

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ence is requested for detailed information on the subject, statistics only being here appended.

STATISTICS—WILMINGTON.

Shipments during the fiscal year ended June 30, 1871.

Articles.	Foreign ports.	American ports.	Total.
Pine lumber.....feet board-measure..	8,334,054	10,026,396	18,360,450
Shingles.....number..	2,712,732	5,627,368	8,340,100
Cotton.....bales..	75	60,140	60,215
Turpentine, (spirits).....gallons..	1,531,283	2,272,637	3,803,920
Rosin and crude turpentine.....barrels..	80,789	409,859	490,648
Tar and pitch.....do....	6,255	25,345	31,600

For the purpose of a more minute description of the rivers, they will be divided into four portions:

The first extends from La Grange to Fayetteville, a distance of eighty-five miles.

The second extends from Fayetteville to Hungry Neck, a distance of sixty-six miles.

The third extends from Hungry Neck to Wilmington, a distance of forty-six miles.

The fourth extends from Wilmington to Reeve's Point, a distance of nineteen miles.

FIRST DIVISION.

The Deep River, from La Grange, flows through the valley of that name, the banks being of alluvion, occasionally varied by sandstone, which, in a few instances, presents perpendicular and overhanging cliffs rising to a height of about 100 feet. The obstructions to navigation consist of falls which are met with at intervals throughout its extent. Owing to the existence of the dams mentioned, these falls were not visible, except at the lower portion. The total fall in twenty-eight and a half miles is about 6 feet, but this is confined to short distances, at Pullen's Falls amounting to 25 feet in three-fourths of a mile. A canal was excavated to pass these falls, which can again be made navigable at slight expense. Thence to Haywood the fall is slight, and no serious obstacle is met with. The Cape Fear flows through an alluvial country to near Averysborough, its width varying from 400 to 600 feet, and the banks being usually low. The principal exceptions to this are at a short distance below Norrington's Dam, where there is a series of rocky prominences from 75 to 100 feet in height, rising perpendicularly from the water, and, in some instances, overhanging. Below Averysborough the river is narrow and the banks high, the soil being very sandy and not much suited to the production of cereals. Fine qualities of yellow-pine timber abound in this portion. From Haywood to Buckhorn Falls, a distance of six miles, the fall is about 6 feet, which is regularly distributed, except at a point opposite Chapman's Island, where, in about 20 feet, it is 1.5 feet, due principally to an artificial dam built for a fish-trap. Buckhorn Falls are one and a half miles long, and the fall in this distance is some 20 feet. These falls were passed by navigable sloughs and a canal, as shown by the map. From Buckhorn Falls to Battle's, two miles, the vertical descent is 8 feet, in a succession of small falls. From Battle's to Norrington, three and a half miles, the vertical fall is 9 feet, and is generally regular, the principal exception being at Bloylock's, where the descent is 2.9 feet over a ledge of rocks. Thence to Fox Islands Dam, eight and a half miles, the difference of level is about 9 feet, confined to several falls, varying from 1 foot to 1.75 feet in short distances. From Fox Islands Dam to McAllister's the river passes over a succession of small falls, the total descent being 10 feet. A series of small falls breaks up the river from McAllister's to Sharpfield Dam, a distance of 3 miles, the difference of level being about 8 feet. Sharpfield Dam is at the head of Smilie's Falls. These form one of the most serious obstacles to navigation on the river, extending for a distance of three and a half miles, with a descent of 27 feet. Three dams were constructed at intervals throughout their extent, viz, Narrow Gap, Green Rock, and Haw Ridge. At Narrow Gap, a ledge of rocks, from 4 to 6 feet above the ordinary bed, extends nearly across the river, leaving a narrow opening near the left bank, whence comes the name; the whole volume of water, *during ordinary stages*, passes through this gap. From Haw Ridge to Fayetteville, a distance of twenty-six miles, the vertical descent is 25 feet, in many small falls, but none of a serious character. Four dams were constructed for the passage of these falls, viz, Red Rock, Silver Run, Jones's Falls, and Cross Creek, the latter being near Fayetteville. This completes the first division, and comprises those portions of the Deep and Cape Fear Rivers which were attempted to be improved by the Navigation Company before mentioned. The means and time at my command during the progress of this survey did not admit of a continuous series of levels being

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taken; recourse is therefore had to those of former surveys, which are believed to be approximately correct.

It is now proposed to improve these rivers by means of a series of locks and dams, as heretofore attempted, using the existing foundations where the locations are suitable, and in other cases good sites can generally be found near those formerly used The estimate submitted herewith is for the construction of 19 river-dams, 2 slough-dams, and 23 locks, of substantial rubble masonry, with guard-banks where needed the dams varying in height from 7½ to 17 feet, and to give a depth of water of 5 feet on the miter-sills of the locks; the lock-chambers to be 120 feet by 20 feet at the low-water line; the whole to be similar in character to those proposed by Mr. William R. Hutton for the New River, on the James River and Kanawha Canal extension.

A study of such data as I have been able to collect, leads me to the belief that the three lower locks and dams may be dispensed with by cutting out a channel of sufficient width through the ledges of rock, forming a sluice and equalizing the fall, or spreading it over a greater distance. An accurate series of levels will be necessary to determine with certainty the practicability and propriety of this mode of improvement.

SECOND DIVISION.

The second division extends from Fayetteville to Hungry Neck, a distance of sixty-six miles, and comprises that portion of the Cape Fear on which, during the summer months, navigation is much interrupted by sand-bars and shoals. The river below Fayetteville flows through a similar section of country to that for some thirty miles above, the banks varying in height from 15 to 40 feet. The bed of the river, being composed almost entirely of sand, is constantly changing from the action of freshets. During the summer months the volume of water is insufficient to give a good channel when spread, as it is, over the whole river-bed; consequently there is no channel, the river presenting a succession of sand-bars and shoals for nearly the whole distance of sixty-six miles. Any improvement of a permanent character in this portion of the river will necessitate the contraction of the channel-way for nearly if not the whole distance, and the estimate herewith submitted is for the construction of longitudinal dikes for sixty miles, leaving their exact location to be determined hereafter. It is believed that dredging will generally be unnecessary, as the action of the water, if confined in a narrow channel, will soon scour out the sand sufficiently.

At Thames Shoals, twelve and a quarter miles below Fayetteville, there is a small bed of clay through which a channel will have to be dredged; an estimate for this purpose is also submitted.

It seems proper that I should mention here that for many years past the company chartered in 1796, as the Cape Fear Navigation Company, have confined their efforts entirely to that portion of the river below Fayetteville, and have exacted the tolls they were authorized to gather by the original act of incorporation and subsequent amendments. They now maintain, during the low-water season, a scow, with the necessary appliances, to remove logs and to cut down and trim overhanging trees.

Previous to the late war there were two lines of steamers navigating the Cape Fear, between Fayetteville and Wilmington. One was known as the Cape Fear Navigation Company line, and belonged to the company mentioned; the other was the Express Steamboat Company line. This latter company had for a long time endeavored to evade the payment of the tolls demanded by the former, on the ground of illegal exaction, but, in actions at law, the courts always sustained the Navigation Company. Since the war these two companies have merged their interests, and have purchased the interest of the State in the old company.

The effect of this procedure was to create a monopoly of the carrying trade on the river, which was said to be utterly ruinous to merchants and other freighters not connected with the company. A number of merchants of Wilmington and Fayetteville combined and purchased two steamers, which they now run under the name of the People's line. One effect of this opposition to the old company has been to reduce freights very materially; in many cases 50 per cent. On precisely the same grounds as the former Express Company, the People's line also seek to evade the payment of tolls to the Consolidated Navigation Company, and the matter is now awaiting a trial in the superior court of Cumberland County. A copy of a memorial to the general assembly of North Carolina, which was signed by numerous merchants and distillers, is herewith submitted. As it would be manifestly unjust that any company should exact tolls where improvements are made by the General Government, and as the secretary of the Navigation Company informed me that the company would continue to exact the tolls unless the Government purchased their stock at a good valuation, the exact status of this company should be ascertained before any improvements are made.

THIRD DIVISION.

The third division extends from Hungry Neck to Wilmington, a distance of forty-six miles, and comprises that portion of the river where the depth of water is always

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ample and navigation uninterrupted. The river here flows through a low country, much of which is swampy. A few bluffs are seen: the principal ones are at Kelly's Cove, Indian Wells, King's Bluff, and Black Rock, which are composed of a dark-blue sandy marl; the other bluffs are simply sandy prominences.

Except the cultivation of rice, and the manufacturing to a small extent of shingles in the swamps, no branch of industry is carried on but the Navassa Guano Works, three and three-quarters miles above Wilmington, where large quantities of guano are manufactured.

FOURTH DIVISION.

The fourth division extends from Wilmington to Reeves's Point, a distance of nineteen miles. The Cape Fear here flows through a low country, on one side consisting entirely of swamps, which have been converted into rice-fields for about twelve miles back, when the banks rise slightly, forming on the right a nearly continuous bluff, principally of clay, and, on the left, being more varied, and containing sand-hills. A short distance below Wilmington the river suddenly expands from about 1,000 feet to upward of a mile in width, which is generally maintained until near Orton Point light-house, when it again increases, and continues to do so, until at Reeves's Point the river is about three miles wide. The effect of this is to cause the formation of numerous bars and shoals which render the channel tortuous and navigation difficult. In addition, there are several artificial obstructions; the first of these is the iron steamer North Heath, three miles below Wilmington, which was sunk during the late war. There is plenty of room to pass on one side of her, and she is, therefore, only dangerous at night or in foggy weather, but she should be removed. A short distance below were placed, during the war, a quantity of floating cribs, secured by chains; these, however, are believed to have become broken up, or to have floated away; immediately below them there were a quantity of iron-pointed timbers, placed in such a position as to rise and fall with the tide, at a fixed distance below the surface; some of these still remain and have been buoyed out, and, as they are dangerous obstructions, they should be at once removed. Perhaps the most serious obstruction in this portion of the river is the shoal of logs commonly known as "the *logs*." The most plausible explanation of what these consist of, and how they came there, is found in the report of the Chamber of Commerce, before alluded to, and is here introduced:

"At a meeting of the safety committee of Wilmington, November 20, 1775, it was resolved that certain members be authorized to procure necessary vessels, boats, and chains to sink in such part of the channel as they might think proper.

* * * * * * *

"A knowledge of the men of that period, with the boisterous circumstances which surrounded them, is sufficient evidence that this order was implicitly obeyed and effectually executed, no report of their action being required or expected. Tradition assures us that these obstacles were placed across the channel at Big Island. We therefore feel justified in saying that the channel, as laid down by all previous maps, was, at that turn and place, obstructed agreeably to the order, as subsequent events would seem to imply. From time to time logs, stumps, and other drift matter, brought down by freshets, lodged against these obstructions, backing up nearly to the narrows, and forming what is known as the flats or shoal of logs, which, as it increased, gradually forced the water through an opening on the west side of Big Island, and, in course of time, scoured out a channel sufficient to accommodate the commerce of the port, and so remained until about the year 1826."

The improvements proposed in the river below Wilmington consist of the removal of the artificial obstructions, "the logs," or such of them as may be necessary, and dredging when required, to secure a 12-foot channel at low tide; the only dredging necessary will be in the vicinity of the logs. I have been informed that an offer was made at one time to remove the logs for $20,000, but have no means of knowing its reliability. The estimates for such improvements as are contemplated are submitted herewith.

To exhibit the value of the trade of these rivers, which would be benefited by the proposed improvements, it is only necessary to call attention to the resources of the country; foremost of which is the mineral wealth of the Deep River country. In this connection I quote Captain Wilkes:

"Although the deposit of coal in the Deep River district will not bear a comparison to the vast fields of that mineral in the Western States, yet, owing to its position, proximity to market, and adaptability to many purposes in the arts, and connected, as it is, with extensive beds of iron-ore, it may be esteemed of great value and interest to the State, as well as of national importance."

Speaking of the iron ore, which is so abundant and of so fine a quality, and of the facilities for its manufacture, he says:

"It is thought by those who have had great experience in the manufacture of iron that there is no locality on the eastern side of the Alleghanies where a better quality of iron can be produced than in the Deep River district, and at less cost.

"There are few places to be found in our country where there is such a concentra-

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tion of material which can be mixed with so little toil and expense; an abundance of the best fuel, consisting of charcoal and the mineral coal susceptible of being advantageously coked, and in great quantity and variety for all purposes of the arts, as well as for domestic uses, fire-clays for refractory furnaces, building materials of sandstone, gneiss, and granite, millstone-grit and fine sandstone for grindstones, clays and sands for the manufacture of glass and porcelain, and a fine quantity of steatite or soapstone.

"The Haw River, near its mouth, furnishes fine water-power, the fall being some 80 feet in four miles. White and red timber, suitable for the manufacture of staves, is abundant in this vicinity. The Cape Fear and its tributaries afford admirable sites for the manufacture of lumber, which can be easily transported to the river, and, were these improvements made, to the sea-board.

Forests of pine furnish the virgin turpentine for the manufacture of naval stores. The swamps furnish an abundance of cedar and cypress for the manufacture of shingles; in short, the improvement of these rivers will develop a country of almost inexhaustible resources extending up into the fertile valleys of the Yadkin and the mining regions of the Deep River.

"Should the exigencies of the Government require it a coal-depot could be easily established in the vicinity of Smithville, near the mouth of the river, and cheap coal produced from the Deep River valley."

Estimates for the improvement of the Cape Fear and Deep Rivers.

First division, La Grange to Fayetteville, 85 miles:

50,641 cubic yards masonry in dams, at $10	$506,410 00
47,861 cubic yards heavy riprap for dams, at $1.50	71,791 00
8,000 cubic yards puddling, at 50 cents	4,000 00
100,000 cubic yards embankment, at 30 cents	30,000 00
Timber, and in coping of dams	12,000 00
23 locks, at $40,000 each	920,000 00
Cleaning out snags	10,000 00
	1,554,201 00

Second division, Fayetteville to Hungry Neck, 66 miles:

316,800 lineal feet dikes, at $1.50 per foot	$475,200 00
15,000 yards dredging, at 50 cents per cubic yard	7,500 00
	482,700 00

Fourth division, Wilmington to Reeves's Point, 19 miles:

Removal of North Heath, Removal of timber obstructions,	$10,000 00
Removal of logs	20,000 00
Dredging 112,000 cubic yards, at 35 cents per cubic yard	39,200 00
	69,200 00

RECAPITULATION.

In the first division	$1,554,201 00
In the second division	482,700 00
In the fourth division	69,200 00
	2,106,101 00
Add 10 per cent. for contingencies	210,610 00
Total	2,316,711 00

Very respectfully submitted.

GEO. H. ELLIOTT.

Colonel WILLIAM P. CRAIGHILL,
Corps of Engineers.

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Q 25.

DISMAL SWAMP CANAL.

UNITED STATES ENGINEER OFFICE,
Baltimore, Maryland, April 30, 1872.

GENERAL: On the 1st of March I had the honor to receive your instructions of February 29, with which was inclosed a communication from the Senate Committee on Commerce, dated February 23, containing a memorial of the Dismal Swamp Canal Company.

I was directed to obtain such information as I could concerning the condition and prospects of that work, and the propriety of complying with the request of the memorialists for assistance from the United States.

On the 13th of March I received further instructions concerning the examination of canals, and was furnished with another communication from the Senate Committee on Commerce, dated February 29, and containing resolutions of the legislature of North Carolina in favor of an appropriation by the United States for enlarging the canal.

The papers referred to me are returned herewith.

It has been impossible for me to make the needed examination in person. It has been done by a most competent deputy, whose services I was fortunate in obtaining. I refer to Mr. William R. Hutton, lately chief engineer of the Chesapeake and Ohio Canal. A copy of his report dated April 22, 1872, is transmitted herewith. It is brief, and necessarily avoids details, but contains all material information supposed to be needed at this time. Its statements and opinions may be safely relied upon.

It is apprehended that some of those who are specially interested in the canal may think more expedition could have been used in presenting this report, but such is not the case. There are large interests involved, belonging to the United States, as well as to other parties, and to form an opinion of any value as to their proper treatment required careful examinations and comparisons, the details of which do not appear in the report, but occupied much time and labor.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

BALTIMORE, MARYLAND, *April* 22, 1872.

COLONEL: In accordance with your request, I submit the following brief report of the result of an investigation of the "condition and prospects of the Dismal Swamp Canal," with a view to its assistance by the Government of the United States.

The limited means and time at my command prevented a very elaborate or exhaustive treatment of the subject, but I hope and believe I have herein presented the case in a sufficiently clear light to enable a decision to be made.

This canal, connecting the Elizabeth River, near Norfolk, Virginia, with the Pasquotank River, emptying into Albemarle Sound in North Carolina, forms a link in the line of interior coastwise navigation from New York to South Carolina. Its length is twenty-nine miles, including a cut of nearly three and a half miles to shorten and improve the navigation of the Pasquotank River. The approaches from both directions are good. The work, as originally constructed, has a surface-width of only 30 feet, with recesses to enable boats to pass each other. The locks are the following: a tide-lock at the entrance, from Deep Creek into the Elizabeth River; two combined locks at Deep Creek Basin; one lock (northwest) ascending to summit-level; one lock (Culpepper) descending from summit-level; two combined locks descending to tide in the cuts leading to Pasquotank River. The structures are in bad repair; the canal

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otherwise in fair condition for the trade which can pass its locks. For considerable distances it has been widened to 40 and 60 feet, and its depth is nowhere, I believe, less than 5½ feet.

The revenue from tolls is insignificant, although it has steadily increased for the last two or three years. The gross receipts in 1870 were over $7,000; in 1871, they had reached $12,700, and I am told that they have been at the rate of $22,000 since September last.

In years past, before the war, the tolls each year averaged about $40,000, the amount received from 1857 to 1860 being $513,260.

The causes of this large decrease are to be found in the depression of business following the war, the bad condition of the canal, the destruction during the war of the only class of vessels of small size which could pass the locks, and finally the construction of the Chesapeake and Albemarle Canal, on a scale to permit the use of much larger vessels, and consequently more economical transportation.

The history of the canal shows that the company has acted with judgment, energy, and upon no narrow policy.

A large part of the dividends have been applied to construction and improvement, and the work is therefore worth more, or rather represents a considerably larger expenditure, than the amount of stock subscribed. In this the United States has an interest of nearly five-twelfths upon an original subscription of $200,000 out of $486,000, from which it is said to have received dividends to the extent of $134,000. The United States has also paid a part of the cost of the improvement of Deep Creek, which has been retained from its dividends to the amount of about $32,000.

Aid is asked from the General Government to complete the enlargement of this canal and its locks to enable it to meet the requirements of the day.

The greater economy of transportation in large vessels is sufficiently established to justify considerable expenditure in construction, and to warrant the expectation of a largely increased revenue. The present locks will pass vessels of from 100 to 110 tons; when enlarged to the scale proposed or recommended, they will be available for those of from 600 to 900 tons.

The improvement consists in the suppression of two locks, leaving (besides the tide-lock) only one set at each end, which are to be greatly enlarged; the lowering of the summit-level 3 feet, and deepening the canal to 8 feet.

There can be no question of the advantages to the canal of the proposed enlargement. Without it the tolls cannot much more than pay current expenses, and the investments in it may be considered valueless.

The United States is asked to contribute to this improvement for several reasons:

1. As a stockholder to the extent of nearly one-half.

2. As a measure of justice, the canal having been used by the Government to a very great extent during the war without payment of tolls, and left in a dilapidated condition.

3. As a means of supplying ship-stores and timber with economy and facility to the navy-yards at Washington and Norfolk, and even farther North.

4. As a promoter of coastwise trade.

5. As a means of defense in time of war.

For the last reasons I recommend that the locks should be made as long as those of the Chesapeake and Delaware and the Delaware and Raritan Canals, or 220 instead of 165 feet. This will not only enable them to pass boats of any size that can get through the others, but will also permit the passage of gun-boats of large size from the Chesapeake, by the interior route, to the sounds of the Carolina coast.

It may be said that all these purposes are answered by the Albemarle and Chesapeake Canal. Without entering into any discussion of the two works, it would appear that at present the Albemarle and Chesapeake Canal does a trade which cannot now pass through the Dismal Swamp Canal. The general, almost universal effect of such works, is to increase trade, and it is quite possible that the business of this part of the country, now just reviving from the effects of the war, may be sufficient to compensate both works for their outlay.

The direct interest of the United States is, however, in the Dismal Swamp Canal, which also possesses, as far as I can learn, certain and decided advantages over the other in distance, in facility of approach, and, perhaps, as a military feature, in its position back from the coast.

No exact information as to permanency of water supply can be obtained. Some remarks of Mr. McAlpine, in his report on the project for supplying Norfolk with water, would imply that, after examination, he considered the quantity available in Lake Drummond to be abundant.

During a recent dry season the present small canal could not be kept up; but I have reason to think it due to the condition of the feeder. Under the new arrangement, the summit-level, being 7½ feet lower than the lakes, 3 or 4 feet of its water may be drawn off for canal purposes, if desired or necessary, which would be sufficient for every purpose.

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The total freights over the Dismal Swamp Canal for the year ending September 30, 1871, was 17,600 tons, in 2,475 vessels or passages. Gross receipts, $12,790. On the Chesapeake and Albemarle Canal tonnage not given; vessels, 4,900. Gross receipts from tolls, $55,778.

The total tonnage received in Norfolk in 1869, by the four inland routes, was about 175,000 tons.

The cost of the improvement, approximately ascertained on the plans proposed by the company, will be about	$410,000
Add for contingencies	40,000
	450,000
And for increasing the size of locks to 225 instead of 165 feet	30,000
Making total cost of enlargement as recommended	480,000

In addition to the above, the company has a bonded debt of over $200,000, say $250,000, making a new investment of $730,000; $10,000 per annum should easily cover administration and repairs, so that, to pay 6 per cent. on this sum, the income should be $43,800.

In arriving at this sum, I have used (except for locks) the quantities of the estimates made in 1867 for the company by Mr. D. S. Walton, civil engineer, reducing them by amounts of work done since, as nearly as can be ascertained, with such modifications as to price as seemed proper in the case.

A recommendation as to the propriety of an appropriation by Congress involves questions of public policy upon which it is not my place to pass.

A certain amount, which I have no means of ascertaining, is probably due the company for the use of the canal during the war.

I have no hesitation in saying that the interests of the Government as a stockholder would be promoted by the enlargement.

Very respectfully, your obedient servant,

WM. R. HUTTON,
Civil Engineer.

Colonel WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

APPENDIX R.

ANNUAL REPORT OF LIEUTENANT-COLONEL J. D. KURTZ. CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pennsylvania, September 7, 1872.

GENERAL: I have the honor to transmit herewith my annual reports for the fiscal year ending June 30, 1872, for river and harbor improvements under my charge, viz:

Delaware Breakwater.
Improving harbor at Marcus Hook, Pennsylvania.
Construction and repair of piers at New Castle, Delaware.
Construction of pier near Lewes, Delaware.
Improvement of South River, New Jersey.
Improvement of Shrewsbury River, New Jersey.
Clearing and improving channel of Schuylkill River.
Improvement of Delaware River between Trenton and Bordentown.
Improvement of Wilmington Harbor, Delaware.

Very respectfully, your obedient servant,

J. D. KURTZ,
Lieutenant-Colonel of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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R 1.

DELAWARE BREAKWATER.

The execution of the original project for the works at this position was completed in 1869. Drawings of the works from a final survey were forwarded under date of 16th July, 1872.

For some years past it has been apparent that the shelter accommodation afforded by the works is not sufficient for the rapidly increasing use that is made of the harbor. Several projects for enlarging the sheltered space have been suggested by the officers in charge of the harbor, from time to time. A board of engineers was convened in October, 1871, to consider the subject. After waiting to obtain the additional information required, the board re-assembled in May, 1872, and its report is or will shortly be submitted to the Chief of Engineers.

As the construction of additional works to enlarge the harbor, whatever design may be adopted, will necessarily require a number of years, it seems prudent to begin at an early time, and therefore an appropriation for this purpose is recommended.

Information of the meteorology of the harbor is very desirable. Efforts were made last year to procure an anemometer for wind-measurements, but no result was reached. It is now expected that a good instrument will ere long be supplied by the chief signal officer of the Army, after a design perfected in his office.

In addition it is proposed to ascertain the direction and force of the wave-currents during the next winter, using the kind of instruments devised and employed by Thomas Stevenson. The movements of the wind and water are the two essential elements of the question. When correctly ascertained they will be of great value for the locality of the harbor, and of some service in addition for the general Atlantic coast. No appropriation is asked for this investigation.

Statement of funds.

Available July 1, 1871	$3,665 33
Expended to July 1, 1872	2,647 06
Available for year ending June 30, 1873	1,018 27

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pennsylvania, July 16, 1872.

GENERAL: Under date of December 1, 1869, Lieutenant-Colonel C. S. Stewart, Corps of Engineers, reported the completion of the Delaware Breakwater and ice-breaker.

The drawings of the finished works were commenced by him, but were not completed for want of some additional measurements of the structures which had been found to be necessary. I have now had the opportunity of obtaining the required dimensions, and the drawings have been completed. They are transmitted in a separate roll by mail, and are as follows:

1. Plan of the Delaware Breakwater Harbor.
2. Plan and sections of breakwater.
3. Plan and section of ice-breaker.

The last general report on the state of these works appears to have been made by Major Hartman Bache, Corps of Topographical Engineers, under date of October 15, 1843.

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The total expenditures to October

Total amount of stone deposited in
835,020 tons, average cost $1.90-6
Contingent expenses 17.963 per cent

Add expenditures for stone depos
July 12 to October 3, 1853, as r
Barnard, Corps of Engineers, O
at $3.62 per ton.....
Contingent expenses .....

Add expenditures for stone depo
to November 4, 1869, as repo
Colonel C. S. Stewart, 50,50-
ton .....
Machinery, labor, and continge

Total cost of the works

Total amount of stone in wor
Machinery, depositing, super

Total cost, agreeing w

The number of vessels r
as follows:

For the six months endin
For the six months endi

Total for the year

This total is larger t
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Brigadier-Gen
Chief of

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Statement of vessels taking refuge in Delaware Breakwater Harbor from September 1, 1833, to January 1, 1872.

Years.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Pilot-boats.	Steamers.	Total.	
1833	22	.....	178	372	167	127	.....	866	From September 1, inclusive.
1834	48	.....	315	669	303	411	.....	1,746	From July 1 to October 17 not recorded.
1835	133	.....	569	1,719	461	644	.....	3,526	
1836	301	.....	1,027	2,719	620	767	.....	5,434	
1837	227	.....	478	2,777	629	732	.....	4,843	
1838	165	.....	732	3,191	765	685	.....	5,533	
1839	165	.....	504	3,561	734	697	.....	5,661	
1840	172	.....	279	1,909	308	371	.....	3,039	To June 3, inclusive.
1841	111	.....	902	3,916	590	403	.....	6,002	From May 1.
1842	107	.....	1,060	5,335	802	794	.....	8,098	
1843	103	.....	841	4,981	1,167	792	.....	7,884	
1844	231	.....	969	5,797	854	744	.....	8,595	
1845	265	.....	1,042	5,446	597	776	.....	8,126	
1846	258	.....	1,625	6,711	614	781	.....	9,989	
1847	342	.....	1,937	7,742	358	874	.....	11,253	
1848	340	.....	1,457	6,037	374	918	.....	9,126	
1849	329	.....	804	3,261	168	553	.....	5,115	
1854	35	247	1,085	5,098	90	.....	114	6,669	From April 1, inclusive.
1855	65	240	855	6,818	128	.....	243	8,339	
1856	116	425	1,062	6,125	256	.....	286	8,270	
1857	79	331	981	5,348	213	.....	220	7,177	
1858	6	34	78	1,030	174	.....	38	1,360	To March 31, inclusive.
1862	55	239	879	8,087	253	.....	246	8,759	From February 1, inclusive.
1863	231	345	1,040	7,092	251	.....	347	9,306	
1864	231	308	1,155	7,781	189	.....	299	9,963	
1865	274	378	1,179	6,056	209	.....	372	8,468	
1866	28	227	694	6,747	299	.....	316	8,311	
1867	113	290	825	8,000	307	.....	279	9,814	
1868	62	446	908	8,373	205	.....	384	10,378	
1869	42	256	658	9,017	696	.....	342	11,011	
1870	126	676	1,157	11,572	756	720	753	15,040	
1871	207	865	1,295	12,552	687	896	80	17,307	
Total	4,989	5,307	28,570	175,827	14,229	12,765	5,044	246,011	

J. D. KURTZ,
Lieutenant-Colonel of Engineers.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 16, 1872.

R 2.

DELAWARE BREAKWATER.

NEW YORK, *August* 29, 1872.

GENERAL: The board of engineers convened by Special Orders No. 142, dated Headquarters Corps of Engineers, Washington, D. C., October 27, 1871, to examine into the condition of the harbor of refuge formed by the Delaware Breakwater, and to report a plan, with estimate of cost, for such additions to or modifications of the harbor-works as may be required to accommodate the existing and growing wants of commerce, having completed the duties assigned to it as above, has the honor to submit the following report:

In pursuance of the order, the board having assembled in Philadelphia on the 8th of November, immediately proceeded to Lewes and visited the breakwater the same evening. Returning to Philadelphia on the 9th, the board met on the 10th, and after careful examination of the reports, maps, charts, &c., it was decided that the information at command relative to the changes in the depth of water in the western por-

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tion of the harbor and outside the ice-breaker was insufficient, in its judgment, for a proper decision of the subject committed to it, and the president of the board was instructed to report the same to the Chief of Engineers. Instructions were also given for the making of further surveys, which should show what changes had taken place since the soundings of 1863, by the Coast Survey, in the portions above referred to. The board then adjourned to meet at the call of its president upon the receipt of the additional surveys.

On Tuesday, the 21st of May, 1872, the board met in Philadelphia in pursuance of call of its president, and examined the further surveys made by Lieutenant Brown, and discussed the subject.

Of the various propositions for modifying the harbor, the three following came under the consideration of the board:

1. To prolong the ice-breaker to the eastward till it laps the breakwater sufficiently to exclude the sea, the estimated cost being $1,944,950.

2. To construct a detached work in advance of the gap of sufficient length to cover it at both ends; the estimated cost being $2,278,000.

3. To fill the gap between the breakwater and ice-breaker with stone, uniting the two structures and making the whole a continuous barrier to the sea, at an estimated cost of $1,314,200.

These several projects have had strong advocates, influenced by the value which they attached to special points of supposed merit presented by the particular plan they preferred. For the first and second projects, it has been claimed that they interfere less than the third with the currents of the harbor, while they still allow of ingress and egress of vessels through the gap between the ice-breaker and breakwater. For the third project it is claimed that it will afford a more secure harbor and a larger protected area than either of the others, by completely shutting out the waves, which would continue to roll with great violence during storms, through the gaps left in the two former.

The third project will interfere with the existing ebb-current between the ice-breaker and breakwater, by forcing this or a large portion thereof to flow between the breakwater and the shore, which change of direction would be beneficial by its tendency to preserve, or possibly to increase, the existing depth in the harbor or protected area.

The growth of the point of Cape Henlopen, which may be attributed to causes similar to those which have produced the elongation of the spit at Sandy Hook, has attracted the attention of the board; but while they do not perceive the probability of evil resulting from this state of things to the entrance between the breakwater and the cape, they nevertheless consider that the adoption of the third project, by causing a greater concentration of the ebb, would probably decrease the rate of gain at the cape.

As to the objection of its preventing access between the ice-breaker and breakwater, the board does not attach much importance thereto, as the harbor is readily accessible at either extremity. The accompanying tables give a record of vessels entering the harbor by the three passages for the six months from January 18 to July 15, 1872. From them it will be seen that out of 3,514 vessels only 994 entered by the passage between the ice-breaker and breakwater, and of these 731 were schooners and sloops, the larger class generally preferring the other passages.

With a view to obtaining the opinions of the members upon the comparative merits of the three projects, a vote was taken upon each, resulting as follows:

First project.—Ayes, none; noes, 5.

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Second project.—Aye, 1; noes, 4.
Third project.—Ayes, 4; no, 1.

The board therefore recommends the third of the above projects for your adoption.

The following maps and charts accompany this report:

1. Map of Delaware Breakwater Harbor, showing the work, as completed, in 1869.

2. Map of vicinity of Delaware Breakwater, by United States Coast Survey, August, 1863.

3. Chart of the Delaware Breakwater Harbor and vicinity, compiled from surveys made under the superintendence of Lieutenant M. R. Brown, Corps of Engineers, 1871 and 1872.

Further reference may be made to the United States Coast Survey chart of the entrance to Delaware Bay and River, of which the board does not possess a copy, to forward with this report.

Respectfully submitted.

I. C. WOODRUFF,
Colonel of Engineers, Brevet Brigadier-General.
H. G. WRIGHT,
Lieutenant-Colonel of Engineers, Brevet Major-General.
JOHN NEWTON,
Lieutenant-Colonel of Engineers. Brevet Major-General.
WM. P. CRAIGHILL,
Major of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

I continue of the opinion already presented in the project for the iron landing-pier of the breakwater harbor, and in my annual report for last year, proposing the enlargement of the harbor, that it is more prudent not to close up the gap between the breakwater and the ice-breaker. The harbor is too valuable for its enlargement to be effected in such a way as to incur any hazard of injury to it. This opinion is the same as has been heretofore set forth by the officers of engineers who had charge of the work during its construction, and who had occasion to discuss the question of enlarging the harbor.

Respectfully submitted.

J. D. KURTZ,
Lieutenant-Colonel Engineers.

Record of vessels that entered Delaware Breakwater Harbor by the three passages.

Passage or entrance.	Steamers.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Total.
January 18 to February 15, 1872.							
Between cape and breakwater	19	0	3	1	157	28	208
Between breakwater and ice-breaker	20	0	3	2	69	6	100
Between ice-breaker and shore	13	4	19	23	79	2	140
Total	52	4	25	26	305	36	448

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Record of vessels that entered Delaware Breakwater Harbor, &c.—Continued.

Passage or extrance.	Steamers.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Total.
February 16 *to March* 15, 1872.							
Between cape and breakwater	15	0	1	11	175	20	[illegible]
Between breakwater and ice-breaker	18	0	1	10	104	10	[illegible]
Between ice-breaker and shore	8	5	22	28	76	2	[illegible]
Total	41	5	24	49	355	32	[illegible]
March 16 *to April* 15, 1872.							
Between cape and breakwater	16	3	5	10	217	19	[illegible]
Between breakwater and ice-breaker	12	0	4	24	140	2	[illegible]
Between ice-breaker and shore	6	1	19	36	132	3	[illegible]
Total	34	4	28	70	489	24	[illegible]
April 16 *to May* 15, 1872.							
Between cape and breakwater	12	1	2	4	169	19	[illegible]
Between breakwater and ice-breaker	5	0	1	4	155	6	[illegible]
Between ice-breaker and shore	3	1	9	20	122	7	[illegible]
Total	20	2	12	28	446	32	[illegible]
May 16 *to June* 15, 1872.							
Between cape and breakwater	13	1	0	5	158	[illegible]	[illegible]
Between breakwater and ice-breaker	14	0	2	7	133	9	[illegible]
Between ice-breaker and shore	6	5	18	37	132	9	[illegible]
Total	33	6	20	49	423	26	[illegible]
June 16 *to July*, 1872.							
Between cape and breakwater	19	1	5	13	237	16	[illegible]
Between breakwater and ice-breaker	16	0	4	16	181	16	[illegible]
Between ice-breaker and shore	17	1	20	42	199	11	[illegible]
Total	52	2	29	71	617	43	[illegible]

P. B. NORMAN
Keeper at Delaware Breakwater Light-House.

R 3.

CONSTRUCTION OF PIER NEAR LEWES, DELAWARE.

At the date of the last annual report, a project for this work had been approved by the Chief of Engineers, and the question of its position was under consideration by the board of engineers constituted for the consideration of the subject.

The board has since approved the position selected by me, and their action has received the sanction of the Chief of Engineers.

Minute and protracted examinations of the bottom of the harbor along the proposed direction of the piers, showed that its materials were too soft and unstable to warrant the work being placed on the indicated line, as 40 feet of muddy and yielding substance would have to be penetrated by the piles of the pier-head before a compact stratum would be reached. This involved great length and diameter for the pile-shafts and largely increased cost of material. The bottom was, therefore, ex

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amined to the westward of the indicated axial line for a less costly site, and one was found requiring a penetration not exceeding 22½ feet, very favorably situated for connection with the shore without change of the initial point of the work, and allowing the axis to be practically perpendicular to the beach. This position is exceptionally well sheltered by the breakwater-works, and, while there is some reduction from the depth of water that the first site affords, the bottom is so soft that this objection disappears, and vessels of the largest draught can lie at the pier-head. The direction of the axis has accordingly been swung through the requisite angle, and the work is established on this line.

The site for the shore-end of the work has been given to the United States by the State of Delaware, and the cession of title and jurisdiction have been approved.

Materials and machinery have been accumulated, the necessary temporary buildings constructed, roads and tramways formed in the sand, the site graded, and the machinery set up.

The actual construction was begun by turning down the first pile into its place on the 15th April.

Much study and time have been given to the determination of the best form of screw, and to devising the several pieces of machinery and modes of application for handling the shafts and inserting the piles with facility in their places. There is little information existing on these subjects. The work is a novel one in this country, and all our labors have been tentative. Embarrassments unlooked for, as well as those anticipated, have been overcome, and the work is now advancing steadily and rapidly, the only difficulty now being to expedite the manufacture and delivery of materials.

A new and important application of the "water-jet," namely, to the top surface, instead of the under surface of the *screw-disks*, has been made by Captain M. R. Brown, Corps of Engineers, who is in local charge of the work, and *self-adjusting* machinery for handling, placing, and turning down the piles has been devised by Mr. A. H. Fisher, the inspector of the iron-work, and by Captain Brown.

These devices and applications render the process of construction easy and regular, while without them it would scarcely have been practicable.

Two hundred and thirty-one feet in length of the structure were completed prior to the 1st of July.

The work will be continued during the present season as rapidly as material can be obtained, and as long as the weather permits. It can be finished next season if Congress appropriates the funds required for its completion.

The increasing depth of water and penetration of the bottom will require longer shafts and of larger diameters. The work will be heavier and will involve submarine labor. This will make it more difficult and tedious, but it is believed that no obstacles as embarrassing as those that have been surmounted will offer in the future.

Expenditures.

Surveys	$1,191 25
Plans, drawings, studies, &c	1,735 50
Field and drawing instruments	500 00
Ascertaining form of screw for piles	2,210 06
Ascertaining character of bottom	4,520 61
Ascertaining sustaining-power of bottom	1,469 93
Machinery and apparatus	12,019 94
Grading-site	398 00
Temporary buildings	5,745 04

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Abutment of pier	$1,398 57
Superstructure of pier-material	7,461 00
Superstructure of pier labor	1,350 00
Materials for substructure	5,389 00
Inserting piles	2,208 36
Bracing piles	150 00
Miscellaneous: Office-work, mileage, stationery, advertising, &c	4,696 15
Total	51,353 45

Statement of funds.

Available for year ending June 30, 1872	$221,007 30
Expended	48,617 94
	172,389 36
Indebtedness July 1, 1872	3,130 61
Available for year ending June 30, 1873	169,258 95
Appropriation asked for year ending June 30, 1874	$163,000
Amount required to complete the work	163,000

R 4.

CONSTRUCTION OF PIER NEAR LEWES, DELAWARE.

Report of Captain M. R. Brown, Corps of Engineers, on duty at Lewes, Delaware, to Lieutenant-Colonel Kurtz, in command.

The close of June, 1871, found this work substantially in the following-named condition:

A board of engineer officers had approved the project submitted by you, and after my return from the execution of surveys which gave full information concerning the currents throughout the harbor and the depth of water in all its eastern portions, had designated, generally, a site for the pier, leaving its exact location for selection in accordance with your judgment after more minute examination of the bottom, &c.

At this stage the proper position for the abutment of the pier was not in doubt, and application for immediate action was made to a commission appointed by the legislature of the State of Delaware to formally transfer to the United States, in the name of the State of Delaware, all title to a tract of land having a front of 500 feet and a depth of 1,000 feet, for the purpose of containing the shore-end of the pier.—(Laws of Delaware, vol. XIV, part I, page 247.)

This transfer was effected August 3, and the boundaries were subsequently marked in a conspicuous and permanent manner. The provisions of the law of the State of Delaware, concerning the lodgment of a plat of the survey, &c., having been fully complied with, the necessary papers and proofs were transmitted to the Attorney-General, in order to procure a certificate in accordance with the laws of the United States, that the title to the tract of land in question inhered truly in the General Government.

Under the date of September 8, 1871, Mr. Akerman, Attorney General, wrote, giving a decision that the title of the United States was good, "assuming that the ownership of the land was in the State when the act ceding the same was passed." This proviso compelled us to procure an assurance of the State's title to the unoccupied lands in the vicinity of Cape Henlopen.

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Accordingly I obtained from Governor Ponder and Secretary of State Paynter, of Delaware, the official certificate of which the following is a copy:

STATE OF DELAWARE,
Executive Department.

To Lieutenant-Colonel J. D. KURTZ, *Corps of Engineers, U. S. A.:*

It affords the undersigned, James Ponder, governor of the State of Delaware, and John H. Paynter, secretary of state of the said State, pleasure hereby to certify that the legal title of the said Jtate to the land on the shore of the Delaware Bay, recently ceded to the United States, for the erection of the shore-end of the pier thereon, pursuant to an act of the general assembly of the said State, in such case made and provided, passed at Dover on the 26th day of January, A. D. 1871, up to the time of the said cession was absolutely perfect and complete as a part of the public land or domain within its limits and belonging to it, that it has been uniformly so considered, recognized, and regarded, alike by the legislature, the public authorities, and the people of the said State, and has never been disputed, doubted, or called into question at any time by any one, since the achievement of the independence of the United States, to the best of their knowledge and belief.

In testimony whereof the great seal of the State of Delaware has been hereunto affixed, and the signatures of James Ponder, governor of the State of Delaware, and John H. Paynter, secretary of state of the said State, respectively subscribed by them this nineteenth day of September, in the year of our Lord one thousand eight hundred and seventy-one.

[SEAL.] JAMES PONDER.

By the governor:
JOHN H. PAYNTER,
Secretary of State.

Having forwarded to the Chief of Engineers this certificate, the following reply was received:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 9, 1871.

COLONEL: Your letter of the 21st ultimo, transmitting the official certificate of the governor and secretary of the State of Delaware, setting forth that the title of that State to the land ceded to the United States for the shore-end of the landing-pier near Lewes is absolutely perfect and complete, &c., has been received.

This certificate would seem to set at rest any question as to the validity of the title to the land referred to upon the part of the State of Delaware, and should be received as sufficient evidence of that title. There is, then, no further impediment to beginning the construction of the pier at Lewes, and you will accordingly proceed with that work as soon as practicable.

By command of Brigadier-General Humphreys.
Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers.

Lieutenant-Colonel J. D. KURTZ,
Corps of Engineers, Philadelphia, Pa.

In the mean time I had occupied myself in testing several screws, cast from patterns heretofore used by engineer officers in the construction of light-houses and other works, in order to ascertain the best form to penetrate the exceedingly hard sand which must be our foundation for the first thousand feet or more of the pier, whatever direction should finally be given to the work. These tests were made on shore, and also from a platform 400 feet out in the water, and were continued after the arrival of authority to proceed with the work.

By the close of October a considerable amount of information had been gained on this important point, and a drawing of a screw had been completed which, it was thought, would combine the good qualities of all under trial. All but one of the seven screws tested had broken after penetrating less than 8 feet, and we had been unable to advance farther than this with any screw without rupturing it. The screw cast according to the drawing referred to above proved to have

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some defects. For instance, no provision had been made for withdrawing it, and in attempting to do so, it broke.

A new pattern was now designed and cast, having the back edges of its flanges beveled, as well as its forward portions. It was made stronger also. This form of screw has successfully withstood tests more severe than any other one tried, and it is inserted with greater ease and rapidity than any other, at all depths, notwithstanding it has a pitch of 10½ inches, while one form tested gained in one turn only 4 inches. It may well be claimed that this investigation is worth far more than its cost.

The screw adopted has double flanges, each making just one-half a revolution. The cutting edges are normal to the hub of the screw and are about two-thirds as long as the longest normal lines of the flanges. Beneath the flanges the point of the screw is quite sharp. The metal of the flanges is 2¼ inches thick where they join the hub, and it gradually becomes thinner toward its edges, until along these it is one-eighth of an inch thick.

A wrought-iron band three-fourths of an inch thick is shrunken on the top of the hub within a recess or shoulder in the casting. The diameter of the screw is 2½ feet. It penetrates 7¼ inches per revolution in hard sand.

Having cleared away all doubts as to the proper form of screw, I was enabled to give more attention to questions concerning the bottom along the line provisionally selected for the pier. This line intersects the breakwater at a point about one-fourth of its length from its easterly end, and has a course north 12½° east, magnetic, from shore.

At 1,800 feet from low-water mark on this line more than 24 feet of water is found at mean low stages of the tide. It was thought that this exceptional depth, combined with the evident permanence of the curves of equal depth here, pointed to this position as most desirable for the pier-head.

My first investigations revealed the fact that beyond the bar we must encounter a very soft and treacherous bottom of mud and clay. The services of a man skilled in artesian-well boring were now secured, and from a raft built on two pontons 4-inch wrought-iron tubing was sunken, at intervals, to the firm gravel, and at intermediate points borings were made with an auger to the same stratum. Specimens of the soil, &c., penetrated were carefully preserved and placed in glass tubes according to a scale. This work was continued under adverse circumstances, since very few days were calm enough for its prosecution, until November 26, when it was thought that a sufficiently thorough knowledge of the bottom along this line had been obtained.

The results were plotted, and have been forwarded. They show briefly that, in order to construct the pier on the line first chosen, it would be necessary to penetrate, during more than half of the work, through 40 or more feet of unreliable mud, having mixed with it clay and sand in small quantities. The proportion of sand and of mud and clay combined in each stratum have been carefully ascertained, and the results are in your possession.

Having ascertained the possibility of building a pier along the line first investigated, but at great expense, the next subject of inquiry was the practicability of constructing the work along some other line, which would, perhaps, afford a less depth of water at a pier-head within moderate distance of the shore, but which would still guarantee a sufficient depth to serve most, if not all, the wants of commerce in this connec-

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tion by affording a landing-place for all vessels which may easily enter the harbor.

To the end of obtaining a solution of this problem, a reconnaissance toward the railroad-pier was made along a line about 1,600 feet from the shore at most points. This examination included careful soundings and probing the bottom with augers and hollow tubing, obtaining specimens of every stratum, and penetrating each to the solid gravel bottom. In this way it was found that, at a point bearing from the abutment north 17¾° west, magnetic, and about 1,600 feet distant from low-water line, the firm gravel-bottom was reached, after penetrating the bottom about 22 feet, and that a stratum, averaging about 5 feet in thickness and nearly 5 feet above the gravel at its lowest point, gave indications of possessing considerable sustaining-power.

A careful examination of the line in question was now made by means of artesian borings, and tests of the capacity of the several strata to sustain vertical pressure. These latter tests had also been made along the line first selected as the site of detailed investigation. The method sometimes pursued was to attach an iron plate, circular, but wrenched open along one of its radii sufficiently to enable it to be screwed into the ground, to the bottom of a rolled-iron rod 2½ inches in diameter, and to screw the rod down by means of the plate at its foot to the desired depth. This was effected between two ponton-boats securely moored.

A cap was then placed upon the upper end of the iron rod, and anchors hung upon projecting hooks were made to bear chains and other heavy weights, until a mark established on the rod by a level so as to be at the same height as a mark on the stationary rod, screwed into the bottom by its side, was observed to be depressed, however little.

The weight on the disk at that instant was assumed to measure the capacity of the stratum tested to bear statical pressure. But the rod bent under excessive weights, bearing about three tons, however. A pile 5 inches in diameter was then procured to test the firmer stratum. Upon the upper portion of this shaft a collar was clamped, and into its sockets oaken bars were inserted, and a platform built on these was made to bear anchors, chains, and other weights.

In order more fully to indicate the reasons which led me finally to recommend the abandonment of the line provisionally chosen for the pier, and the adoption of the line on which we are now working, I insert here an extract from a former report made to you:

Reasons for preferring for the axis of the pier a line bearing from the zero of the abutment north 17¾° west, magnetic, above all others, including the line bearing north 12½° east, magnetic, from the same point.

The line first designated above will, in this report, be called "line No. 2," and the second named, (which was first recommended as a site for the pier,) will be known as "line No. 1." The numbers indicate the chronological order in which profiles, showing the depths of water and nature of the strata constituting the bottom to a considerable depth along these lines, were determined.

After a careful and extended investigation (of which an account is given in an appendix) to ascertain the relative merits of various directions for the projected landing-pier, including all that are practicable, under the restriction forbidding consideration of any that would not afford a sufficient depth of water at the pier-head, I have been led to recommend "line No. 2" for the following reasons: Although less favorable in respect of depth of water than "line No. 1," it will afford a good depth within a short distance from shore. A pier 1,701 feet long, on "line No. 2," having a pier-head 504 feet long, would afford, alongside the latter, a maximum depth of water of 21.3 feet, a minimum depth of 12.3 feet, and an average depth (the mean of twenty-five depths measured 20 feet apart, beginning at the point farthest seaward) of 14.9 feet. Assuming the same lengths, with the same system of measurements, for a pier and

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pier-head on "line No. 1," we should have for the maximum, minimum, and average depths, respectively, 24 feet, 17.9 feet, and 3.5 feet.

Extending a pier-head of the same length on "line No. 2" to a point 1,848 feet from the abutment zero, we should have for maximum, minimum, and average (as above) depths, in order, 21.3 feet, 12.3 feet, and 14.9 feet. For "line No. 1," under the circumstances last considered, the maximum, minimum, and average depths would be, respectively, 24.4 feet, 16.1 feet, and 22.5 feet. The differences, apparently, greatly favor the selection of "line No. 1." But when it is considered that the bottom, under deep water, throughout the lower portion of the harbor, consists for the first 5 or 6 feet of soft mud, in which a vessel may sink at low water, to rise with the tide, it seems probable that any master of a vessel, desiring to avail himself of the facilities of a pier built on either site, could do so without injury or inconvenience to his charge.

Any vessel, which can now enter the harbor, could lie at the pier-head on "line No. 2," were its outermost position placed 1,701 feet from the zero of longitude measurements.

My own observation, corroborated by the opinion of the most intelligent residents of this neighborhood, indicates that in the more violent storms which occur on this coast, "line No. 2" is, on the whole, as calm a position as could be chosen, and, in this respect, is preferable to "line No. 1."

If, through any adventitious or artificially induced causes, the bottom of the harbor should ever be subjected to a violent scouring action, which should seriously affect that portion nearest to Cape Henlopen, the bottom along "line No. 2" would probably experience less abrasion than in parts of the harbor nearer its mouth, since, under the conditions imagined, the point of the cape, returning toward its former position, 660 feet farther to the southward than its present site, the most easterly portions of the harbor would no longer be sheltered from the fury of east winds and the effects of incoming storm-tides, and the scour of untrammeled and increased ebbs might seriously endanger foundations placed too near the Atlantic. Uniform weight would not be given to this hazard by different winds. Probably all would concede some importance to this consideration, however. Its value is vague, but it may assume more definiteness in years to come, with the progress of additions to the works which make the artificial harbor of the Delaware Breakwater.

"Line No. 2" is more accessible than "line No. 1." The various shoals near to and east of the latter would, in many conditions of the wind and tide, render difficult a gentle approach to a pier built on this line. It would be necessary, within a short distance of the pier, to make a sharp turn to the southward, and therefore to preserve a considerable headway until quite near to the structure. "Line No. 2" is, however, quite accessible.

By a prolonged and sufficiently minute examination of the bed of the harbor, by means of borings with artesian-well tubing four inches in diameter, and the use of augers and other devices, it has finally been ascertained that a thoroughly good sand foundation for the pier-head cannot be reached anywhere in the harbor at a less depth (in mud, &c.) than 20 feet, without sacrificing depth of water.

Probably a depth at mean low water of 15 feet may be had by sinking the bottom of the piles 10 feet, and they may then rest on moderately hard sand. It is exceedingly doubtful if more than this can be attained without building in mud or going deep to a stratum of firm sand and gravel containing stones of such size that we have generally been able to penetrate it only a few inches without reaching a stone too large to come up through 4-inch tubing.

The first test to ascertain the amount of statical pressure which a given area of the bottom at various depths will sustain, was made at a point 1,650 feet from low-water mark on "line No. 1," which was then presumed to have a bottom quite as good as could be found in the harbor, without sacrificing the prime consideration, deep water. A leaf from the journal of October 10, 1871, is here copied to show the result of this test:

"*Tuesday, October* 10, 1871.—At 1,650 feet from low-water mark, on 'line No. 1,' I sunk a screw nearly a disk, one foot in diameter, attached to a rolled-iron rod 2¼ inches in diameter, by statical pressure. Counting weight of rods, &c., 900 pounds depressed it 3 feet; 1,650 pounds depressed it to 7 feet, then to 8 feet, then to 10¼ feet; 1,800 pounds pressed it down to 11 feet; 2,500 pounds sunk it to 11½ feet below the surface of the bed of the harbor. We then screwed down the flange to 21 feet, and, after numerous experimental pressures and much time passed in putting out anchors, steadying rod, &c., we put on about three long tons, that is, 6,700 pounds, and the flange did not sink any, although the rod bent as the raft swayed."

Until several borings and soundings had been made it had been hoped that an ultimate sustaining capacity, nearly or quite equal to that shown in the experiment described above, could be relied on for the foundations of the entire pier-head, should it be so built that its outer end should be 1,869 feet from the abutment, or 1,804 feet from low-water mark, but as the borings and soundings progressed the prospects grew less and less favorable, and when such investigations as were considered indispensable were completed, it was found that in some places a safe foundation could be reached

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only by a penetration of at least 40 feet into the bottom, or quite 64 feet from mean low-water mark, and that for many points on this line we would have to provide piles 75 feet long. An examination of the drawings heretofore sent to you shows that the stratum on which my disk rested in making the first test is wanting for a distance of 265 feet, and that it would be better to go to the firm gravel, all things considered, throughout the entire pier-head on this line, than to rest the flanges of the screws in anything nearer the surface. I found that a rod inserted 39 feet into the bottom, at a characteristic point on this line, could be freely moved about from a boat on the surface of the water, 60 feet from the base of the rod, which was a flange 12 inches in diameter, with so much ease as to require a very slight exertion of strength to cause it to deviate many degrees from the vertical.

In connection with the fact that the same sand and gravel stratum, so hard and firm that we have nowhere succeeded in penetrating it more than 6 feet, is found 20 feet nearer the mean low-water surface on "line No. 2" than on "line No. 1," should we not reflect on the possibility that, in former times, when the point of the cape was 600 feet farther southward, the effects of the tides on "line No. 1" were at times so violent that this gravel stratum was denuded through many feet of its depth, and that "line No. 2" gained a part that the other lost? This view cannot fail to give some appearance of validity to the apprehension before alluded to, that the tides may again in the course of time violently disturb the bottom along "line No. 1." The presentation of these points seems to be quite sufficient to show that "line No. 2" is, all things considered, much safer and better to build upon than "line No. 1."

The next point in order demanding our attention is with reference to the choice of a stratum of "line No. 2" in which to rest the flanges of the screws to be attached to the iron shafts of the pier. In this place it is proper to introduce such data as our experimental tests present, and for this purpose copies of portions of the entries in the journal of operations for the 4th, 11th, and 13th of January, 1872, are now inserted:

"*Extracts from the journal of operations.—Construction of an iron landing-pier near Lewes Delaware.*

"*January* 4.—The ponton-raft was moored at a point 1,440 feet from low-water mark, bearing north 17½° west, magnetic, from the center of the abutment foundation. Two piles, 5 inches in diameter, each 22 feet long, firmly connected together, and having a disk 12 inches in diameter near the end of the compound pile, were lowered. The weight of the shaft and auxiliaries was 3,500 pounds. This weight sunk the disk 15¼ feet in the bottom. Forty-two hundred and fifty pounds were then loaded on the pile, when it started and went down 3 feet, where it was upheld by the raft. The pile was then unloaded, and the process of raising it began. When it had been elevated 8 feet, the straps slipped, allowing the pile to fall. It penetrated by its momentum 20 feet and 3 inches into the bottom. It was then raised without reversing and taken ashore, and the 16-inch disk substituted for the 12-inch. It should be remarked that although these are spoken of as disks, they could be inserted as screws, being split open, and having a pitch for this purpose. This result indicates a holding power of 9,866 pounds per square foot.

"*Monday, January* 8.—The double pile, having the 16-inch disk at its lower end, was taken again to the point occupied January 4 and lowered. It sunk of its own weight (3,500 pounds) 11 feet in the bottom. It was then screwed down 5 feet 6 inches farther, and a collar and lever, weighing 660 pounds, all told, and 9,000 pounds of chain, were loaded on it without depressing it. After allowing it to remain a short time, eight men, weighing together 1,357 pounds, were added gradually, when it slowly settled 6 feet 3 inches more, or until the levers rested on the ponton. The weights were then removed, the pile buoyed and left standing, to see what effect the tides of the night would have. In all, 14,517 pounds had been required to depress the disk.

"The 12-inch disk had been but 15 feet 6 inches in the bottom, while the 16-inch disk had penetrated one foot farther. Neglecting this difference of conditions, let us see if the 16-inch disk sustained relatively its proper weight according to theory.

"COMPUTATION.

$$12^2 = 144$$
$$16^2 = 256$$

"The 16-inch disk should have sustained $\frac{256}{144}$ of the weight necessary to depress the 12-inch disk, or $\frac{4}{9}$ of 7,750 pounds $= \frac{12400}{9} = 13{,}777$ pounds; 14,517 pounds $-13{,}777$ pounds $= 740$ pounds, the excess over the number given by the ratio. So far as it goes, this would seem to confirm Mr. Alexander Mitchell's theory, that the sustaining power afforded by a disk of a certain diameter bears a greater ratio to that given by a disk of smaller diameter than the ratio of the area of the larger disk to that of the smaller. To-day's test shows a holding power of 10,338 pounds per square foot of the stratum tested.

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"*Thursday, January* 11.—Fourteen hundred and forty feet from low-water mark, as nearly as could be determined, the pile was lowered, and sunk 13 feet of its own weight and that of its adjuncts, 3,500 pounds. About 3,000 pounds of weights were now added, and the wooden arms inserted into the collar which clasped the pile sank to the deck of the raft. As it was then high water the apparatus was allowed to remain three hours. On returning, it was found that the disk had sunk until it was in the bottom 15 feet and 9½ inches. More chain was piled on until it began to settle again. Marks were made on the shaft, and on an unloaded rod, inserted into the bottom alongside, so that both lines were in the same horizontal plane, determined by a spirit-level. After half an hour it was found that the shaft had settled half an inch. Throughout another half hour it remained stationary. The pile was now taken up, and it and the chains were taken ashore and the chains were weighed. It was found that the chains and levers weighed 3,650 pounds, and the collar 560 pounds; total weight, 4,210 pounds. Adding the weight of the pile-apparatus, we find that 7,710 pounds loaded on a 16-inch disk was the utmost that the bottom would sustain at a depth of 15 feet 10 inches. It would appear, then, that we must penetrate the bottom 16 feet 6 inches to obtain a holding power of 9,800 pounds per square foot of foundation indicated by the experiment of the 4th and 8th of January, the superficial area of a disk, 16 inches in diameter, being 201 square inches. The support per square foot indicated by to-day's experiment is $\frac{7}{10}\frac{1}{1}\frac{0}{4}$ of 7,710 = 5,544 pounds.

"*Saturday, January* 13.—Fifteen hundred and ten feet from the zero of the abutment, a pile, 16 feet long and 5¼ inches in diameter, was lowered. It sank in the mud, by its own weight, 9 feet. It was raised, and 560 pounds were added to it. It was then lowered again, when it sank 14 feet 6 inches. A pile 18 feet long, of the same diameter, was then lowered, and it sank in the same place 16 feet, of its own weight. These experiments show that a 5¼-inch disk, sunken here 16 feet, will sustain about 1,317 pounds, or that, at the same rate, a 1-foot disk would support about 6,897 pounds. To-day's work has also shown that the stratum under test has its continuity impaired by disturbance, and that it does not nearly instantly become compact, after being loosened, as the firm sand nearer shore has done in all cases that have come under observation."

The main object of these trials was to test a stratum, consisting of from 80 to 90 percentage by weight of moderately coarse siliceous sand and of clay and mud. It extends through about 6½ feet vertically, and begins about 1,250 feet from shore, measured on "line No. 2." Its highest point known to me, relative to the harbor's bottom, is at the place tested, and is 12 feet from the plane dividing the water from the mud. It is separated from the firm sand and gravel stratum, found lower, by a layer of mud very soft and compressible, and about 4½ feet thick. It appears from the data obtained that the foundation-screws should rest at least 16 feet in the bottom, otherwise the matter beneath the flanges of the screws will support in some places less than 2½ tons per square foot. It must be borne in mind that, after a penetration of 16 feet, we have only about 1 foot between the flanges and the soft mud. Hence it is uncertain how much the final resting of the flanges in these trials depended on actual compression of the strata.

A reference to the accompanying table, (Appendix B,) showing the percentage by weight and nature of the sand obtained from specimens taken from the various strata at different points in connection with the drawings forwarded, exhibiting the position and boundaries of the various layers, and the description given above of the tests made, will, it is believed, show sufficiently plainly that it were better to rely on a sustaining capacity of no more than one ton per square foot of foundation, even at a depth of 16 feet in the bottom. Mr. Alexander Mitchell and others tell us that five tons or more measure the upholding power of good sand. A screw 5 feet in diameter would probably bear more than 29 tons, were it depressed 16 feet at the place where the most unfavorable results were obtained; but were this load to press on any one screw, the factor of safety would be far too small. A reliance on this stratum would manifestly be hazardous.

It is believed that the tests already completed, having been made at representative places, are all that are needed to bring us to this point

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in our conclusions, and that our attention should next be directed to the more promising stratum which may be reached by sinking the shafts only 5 feet farther.

It is by no means certain that the difference in the cost of the screws required for these two strata, respectively, and the additional time and power requisite to insert screws of 5 feet in diameter, having a very slight pitch and great thickness of flange, would not more than compensate for an increase of 5 feet in the length of the piles, necessary to enable us to rest our foundation-screws on the gravel stratum. Neither should we overlook the possibility that a screw for a soft and compressible bottom, having a diameter of 5 feet, might be partially stripped of its flanges in penetrating 16 feet. Only actual practice could establish the feasibility of inserting screws so large, with a reasonable expenditure of time and money, and the certainty of avoiding the danger of destroying the foundations in putting them down at this site.

There can be no doubt that a diameter of 2 feet 6 inches is ample for the flanges of screws, which are to rest on the excellent bottom found about 40 feet below the plane of mean low water. Again, it would seem that a solid wrought-iron shaft, of the proper diameter, resting in a firm bottom, having an appropriate screw, and strongly supported laterally by the stratum which would be the second choice for a foundation, when moderately well braced transversely and longitudinally in vertical planes, is, considering the great support given it by the superstructure itself, quite strong enough to bear any stress it will have to sustain, in aiding to supply the demands of a landing-pier at this locality. But were the screws to rest in the less firm stratum nearer to the low-water plane, it would perhaps be only ordinary prudence to add a set of diagonal braces or ties (to serve both offices) in a horizontal plane nearly coincident with the top of the surface mud. A small disk, sunken in the upper of these two strata, is easily made to rotate about an axis through its center in any direction.

It is not so in the firmer strata. Hence the need of greater precaution, if the upper bed is to serve as a foundation for the flanges. These considerations constrain a preference for that stratum.

For a foundation whose sustaining power is ample and undoubted, careful tests made late in the month of March, or as soon as a pile 5 inches in diameter and 52 feet long could be procured, showed that the firm gravel stratum in "line No. 2" is capable of sustaining about 15 tons per square foot. There remained then only the presentation by you of the facts herein given to the Chief of Engineers and his approval of the prosecution of the work along the line north 17¾° west, and of the proposition to penetrate to the firmest stratum reached, before giving the first order for the material to the manufacturer. The necessary authority was soon procured.

Previously, or as soon as it became clear to my mind that the line north 17¾° west would be chosen as a site for the pier, with your approbation, on January 13 I began the construction of the abutment. It was completed February 23. The stone had been raised from abandoned cargoes of various vessels wrecked in the harbor many years ago. A portion was of brown sandstone, in large blocks, quite regular in figure, but rough from long exposure to the action of the wind and waves and the chemical action of the water. This was dressed on its outer sides by a stone-cutter hired for the work. The remainder of the stone was granite in rather thin slabs of no great size. The latter was made to serve for the foundation. The abutment is, including two short wings, 36 feet long, measured on axial lines. Its foundation, which

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extends to low water, is 6½ feet wide. The superstructure is 4 feet wide. The front line of the abutment is 60 feet from low-water mark, measured horizontally. The total height of the abutment, from the lowest course of the foundation to the cap-stones, is 11⅓ feet.

The erection of the necessary temporary buildings was begun October 24, and finished December 20. They are six in number, as follows: carpenter's shop, blacksmith's shop, store-house and office in one, stable, boat-house, and a small scale-house. All are one story, except the stable and store-house, which are one story and a half in height. They are all well built, and as the material was procured at a low rate in the neighborhood, they will doubtless bring a fair share of their first cost at public sale, if they are kept in good repair in the mean time. The site on which they stand, chosen in consideration of its proximity to the shore end of the pier, was very rough originally, being on a ridge of sand-hommocks. It has required considerable labor to grade it sufficiently to make transportation from the outside and between the various buildings practicable and easy. To this end a substantial but inexpensive tramway of plank, on longitudinal girders, has been built, passing all the workshops, and a truck has been constructed which runs on the tramway and bears heavy loads from the blacksmith's shop, &c., to the pier and in return. This has proved an almost indispensable convenience.

One of the first questions which presented itself on assuming superintendence of the work was that concerning the kind of power which should be employed in the construction of the pier. My preliminary experiments plainly showed me that man-power would be too expensive, since forty men were unable to cause the screw to penetrate more than 8 feet. Steam-power, at the first, seemed too *unsympathetic*. Some form of power was needed whose exact measure could be read each instant by the overseer's watchful glance; otherwise, should any unusual obstacle be encountered in the process of screwing down the piles, a disaster entailing serious delay and expense might result. Horse or mule power seemed to be the *desideratum*. After testing horse-power in grading the grounds for the buildings, I saw that these animals would probably lack in steadiness and reliability. I procured some mules from the neighborhood and tested them, but they were small and lacking in stamina. Finally, in Philadelphia, after careful search, I obtained seven excellent heavy mules. They have proved equal to everything that has been required of them, and, if they could not be replaced, they would be invaluable.

Another problem, which called pressingly for solution, was to devise some method of connecting the power to be applied with the pile-shafts to be screwed down. All processes described in such accounts of similar works as I could find, seemed crude, slow, and unnecessarily expensive and laborious, when it was considered that we must put in place about three hundred piles, instead of five or nine, as in the construction of most light-houses.

Some engineers had adopted ribs running down the sides of the piles longitudinally, fitting into corresponding slots in the collar which held the levers. Others had used piles containing longitudinal slots corresponding to projections from the collars. Still others had set small screws into the head of the pile by pressure, and from a small collar thus supported had hung chains which, in the actual operation of turning, were wrapped about the pile one or more times, forming a Spanish windlass, in fact.

It was desired to avoid placing anything in or on the pile which is

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not needed when it is in place. The Spanish-windlass arrangement obviated this, but the chains were constantly breaking, endangering the lives of workmen, and monopolizing the time of the blacksmith to keep them in repair. Besides, the spring of the chain used up a considerable portion of the motive-power.

The first new device I tried consisted essentially of a collar in two parts, holding four segments of steel, drilled to have several hundred small diamond-shaped points, the surfaces of the segments fitting accurately to the cylindrical surface of the pile. The segments could be taken from the collar and others of different curvature substituted, in screwing down piles of different sizes.

The two halves of the collar being firmly clamped together, the points take hold of the metal of the pile, and, if no slipping occurs—and, if all due precautions are taken, none will—with the application of at least eight mules, full power, at the end of levers 17 feet long, the device is good. But, for want of perfect fitting between the segments and the pile, on several occasions, when using the amount of power above designated, the collar slipped and scarred the pile to the depth of about one-twentieth of an inch. With the amount of power now used in putting down the piles, no slipping could ever occur. The disadvantage of this device is that it needs careful turning of the nuts which press the halves of the collar together. This consumes some moments.

A second very ingenious device, the credit for which is due to Mr. A. H. Fisher, inspector of iron for the pier, consists of a collar, in one piece, having three recesses shaped like a wedge, which has been bent partly around a cylinder, the axis of the wedge just before the bending having been at right angles to the axis of the pile. A steel pin or roller is dropped into the recess and held from below. In turning, the roller passes into the smaller portion of the recess, becomes jammed there, and the collar is fixed. The disadvantages of this device are: First, that it is difficult to drive out the roller, when an excessive amount of power has been used. This may be remedied by modifying the shape of the roller and of the recess. A second disadvantage is that this form of collar, after all, requires a clamp-collar beneath it to hold it up; and as this has to support great weight, extreme care is required lest the lower collar, not being clamped tight enough, the whole turning-apparatus may fall. Such an accident has once occurred, causing considerable delay from its consequences and some pecuniary loss; but, almost miraculously, no loss of life. Both of these forms of collars have been very useful, and I desire here to express my obligation to Mr. Fisher for his apt and ingenious assistance in this and in other particulars of office work.

After the accomplishment of the results referred to above, there still remained unanswered two most important questions. One of these related to the best manner of applying mule-power to the work in hand; and the other was, is it possible to insert piles to the depth of 10 feet in the hardest sand, where wooden piles can only be driven about 5 feet, or to the place where the extreme hardness begins? As to the first point it was clear that, if the mules could be successfully worked on the built portion of the pier, we should save the enormous labor involved in frequently moving a staging and its supports, and, besides, we should be independent of the condition of the water.

The solution of these two questions was left to be found during the insertion of the first few piles of the pier.

All preliminaries having been settled, on the 15th of April I began the work of screwing down the first pile. The strata to be penetrated

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here on shore were all coarse. After the first 2 feet they are made up mostly of small pebbles, and yet they contain grains of so many different sizes that the mass is very compact and extremely hard to penetrate. Nevertheless, we succeeded in causing the screw to go down 9 feet, the desired distance. As this was an extreme case, and it was taken for granted that some method of easing the insertion of the screw would be used, so that the great strain brought on the pile during this attempt should be exceptional, I now knew that the question relating to the proper manner of utilizing the power of the mules was answered. In this method, white-oak levers 19 feet long, and 6 inches by 8 inches at the butt, were employed. Around the ends of these a 6-inch rope is passed three and a half times, the same rope being passed around an anti-friction cylinder about one hundred yards in the rear. Seven mules, connected with the main rope by fourfold tackle, constituted the power used on the day in question. The strain was so great that the 6-inch rope broke several times before we succeeded in inserting the screw to the required depth. A cast-iron anti-friction guide with steel rollers, attached to a stiff piece of timber laid horizontally on the level of the top of the pier, aids in holding the pile in place. Four other iron rings or collars also aid in this work, two on each of two strong oaken frames. One of these frames is doubly clamped to the pile of the same longitudinal row, and just in rear of the pile being inserted. The other is in the same way clamped to a pile to the right or left and rear. These frames are also supported by seats, which rest on the bed of the harbor.

In order to indicate the manner in which the second question above referred to was answered, I quote from my monthly report for April, 1871:

Several attempts have been made to sink a pile by passing iron pipes through the flanges of the screw and forcing a jet of water beneath. They have not, so far, been successful, but the prevalence of gravel on and near the shore has caused the tests to be made under unfavorable conditions. Again, the force-pump in use is not powerful enough. It is proposed to procure a better pump and renew the experiment farther out from the shore.

In attempting to set the second pile the screw broke, the flanges being stripped off completely from the hub. Holes were now dug in the coarse sand and gravel until the screws themselves were required to carry the pile down scarcely 3 feet, and in this way the next two piles were set in their places, penetrating in all about 9 feet. As the gravel becomes somewhat finer in mooring out 20 feet from the first bay, it was hoped that we might here succeed without digging. You were present at the trial, having arrived the preceding day, *i. e.*, Monday, 22d day of April. The screw broke, partly at a depth of 7 feet 6 inches, and partly 4 inches deeper. It now became evident that the screws were intrinsically too weak to sustain the pressure imposed on them. Accordingly, I investigated the nature of the strata near the shore, in detail, and found that the gravel is about 3 feet thick only; at a point 63 feet from the abutments, rear I also tested the sustaining power of the firm sand, 10 feet below its upper surface, and found, as indicated above, that a disk 2 feet in diameter would bear 64 tons with an ultimate depression of only one-thirty-second of an inch.

It was evident, therefore, that we might safely diminish the diameter of the screws.

The piles of the second bay were successfully placed by digging, and then screwing them down to the required depth. This process was not only very tedious, but after the second bay we must work at and below the water-mark, and digging would no longer be feasible.

An examination of the fragments of the flanges had shown me that the greatest resistance encountered is on the upper surface of the flanges, and is doubtless due to the friction caused by the direct weight of the superimposed cone of sand, and to the opposition of a component of this weight to the motion of the screw's flanges.

It occurred to me, then, that if a jet of water were to be forced upon the upper surfaces of the flanges of the screws while the rotation is in progress, it would perhaps accomplish, first, the lubrication of the surface most exposed to the friction between the sand and iron; and second, if I could succeed in liquefying the sand above, I should change the pressure on the flanges from that due to the frustum of an inverted cone to that due to a cylinder whose diameter would be that of the smaller base of the frustum. I therefore pumped a stream of water through two one-inch iron pipes from a force-pump directly upon the flanges, and the operation of screwing down the

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piles was at once eased. It is quite safe to say that two-thirds of the pressure was immediately relieved.

Since the success of this attempt, no difficulty has been experienced in inserting the piles, and it is confidently believed that the method now used, *i. e.*, working mules always on the built portions of the pier, and passing the fall three times around the ends of the levers, whence it passes to an anti-friction cylinder 100 yards in the rear, combined with the use of the water-jet as above described, solves the problem as to the successful construction of the pier, along a line beset with unusual difficulties from the nature of the bottom. I had two screws cut down to a diameter of two feet, in order to test the ease of inserting such foundations. But I now recommend that I be furnished with fifty screws of the last Wilmington pattern, without holes for water-jets.

As soon as a new invoice of screws arrives, it is proposed to endeavor to insert a screw to the depth of 10 feet, by the aid of the water-jet. If this attempt succeeds, I recommend that the piles be ordered in the future to be 1 foot longer than the length necessary for the insertion of 9 feet in the bottom.

The attempt referred to has since succeeded, and the recommendation indicated has been made and adopted. A more powerful pump, worked by mule-power, having been purchased, it is found practicable to insert the piles to a depth of 12 feet 3 inches. This is as far as we shall have occasion to penetrate this hard stratum. It is believed, however, that no great difficulty would be encountered, having pipes the proper length to convey the water-jets to the flanges, in attempting to penetrate 20 feet, or even much farther than this. The last foot of the work, in penetrating 12 feet 3 inches, was accomplished seemingly as easily as the first foot in the same stratum, classifying according to hardness of strata.

It is believed that the sand here, from 8 feet to 12 feet from its upper surface, is as dense and difficult to penetrate as any met with in laying foundations, and it now seems certain that in similar sand the foundation-screws for iron light-houses may be sunken as deep as may be deemed desirable. This is perhaps the most important truth discovered in the progress of the work, and the opinion above expressed is advanced confidently. It is well known that many engineers have been obliged to rest their foundations heretofore in like cases far above the position desired on the score of practically perfect safety and stability.

The force-pump used to accomplish the result above indicated has a cylinder 5 inches in diameter.

It is worked by one heavy mule in what is commonly called a "tread-mill." The hose nearest the pump is 2½ inches in diameter. It soon diminishes to 2 inches, however, and the stream of water is ultimately divided into two jets, each filling a galvanized iron pipe 1¼ inches in diameter. The cylinder of the pump holds six pints of water, and the pump is worked at a velocity indicated by 80 full strokes per minute.

While excessive power was found necessary to screw the piles down a moderate distance, it was thought best to employ oaken levers 17 feet long and 6 by 8 inches at their but-ends. Sockets of cast iron were provided, weighing each nearly four hundred pounds, into which the but-ends of the wooden levers were inserted. The solid ends of these sockets were 4 inches deep by 6 inches wide, and were inserted into sockets of these dimensions left in the casting, which we have called a collar. On the discovery of the new application of the water-jet, these heavy iron sockets were discarded, and oaken levers only 7 feet long and measuring 4 by 6 inches at their but-ends, were inserted directly into the collar. They were so arranged as to give in effect eight lever-arms, the ends of each having guards to hold the rope effectually. The whole apparatus used in turning the pile is permanently put together and is lifted from the pile just screwed down to the pile

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just ready for that operation. In this way a great saving is effected, as with the cumbersome apparatus necessary before the new application of the water-jet, several hours were sometimes necessary to adjust the parts before the work of turning the pile could be commenced.

The derrick adopted is capable of use in screwing down the three piles of each row, without being moved from position.

Since it has thus far been found impossible to procure materials so fast as possible construction requires them, a full force of men has not been employed. With a force of 25 laborers it is believed that 15 piles per week could be put in position. Fourteen laborers (besides four carpenters and two blacksmiths, three teamsters, and one watchman) constitute, with the overseer, the entire force permanently employed. Much of this economy of workmanship is due to the skill and energy of Mr. John Walker, the overseer.

One hundred and ninety-one thousand feet of yellow-pine lumber, of an excellent quality, from Apalachicola, Florida, have been received, thus far. Two hundred and forty-one thousand feet of lumber are still due. At the close of the year, June 30, 1872, 231 feet of the pier were completed.

Arrangements are so well systemized that it is safe to say that all the material forwarded during the present working-season can be put in position nearly as soon as received. At the present, while at work on the narrow portion of the pier, 400 feet per month can be built; afterward, progress will be slower, necessarily. But it is probable that 100 feet per month of the pier-head, which is to rest on piles 8 inches in diameter and, in some cases, 54 feet long, can be built. At this rate the entire amount thus far appropriated, $250,000, will be expended before next spring. The above estimate assumes a fair amount of good working-weather. But if the winter is a favorable one, much can be done during that season.

The entire bill of lumber needed in the construction of the pier is contracted for, and will be delivered this summer and fall, probably. The iron necessary for 1,197 feet of the pier is under contract, including the swell of the structure, where the narrow or bridge portion conjoins the pier-head.

A condition of the iron-market more favorable to purchasers should be awaited, perhaps, before advertising for bids. Or if it is necessary to advertising soon, it will probably be found economical to call for bids for a portion only of the iron needed for the work.

There are appended to this report a sketch and tables accompanying a former report, made March 14, viz, summary of steps leading to a change in the direction of the pier; sketch illustrative of the same; table, showing proportion and nature of the sand contained in the strata examined. They are thought to be of sufficient importance to require an insertion in this paper.

A detailed statement of expenditures in the construction of the pier, including the cost of labor and of the lumber, iron, and other materials, delivered to June 30, 1872, is forwarded in a letter accompanying this report.

Very respectfully, your obedient servant,

M. R. BROWN,
Captain Corps of Engineers, U. S. A.

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APPENDIX A.

The following summary shows briefly some of the steps taken which led to a minute investigation of the bottom along the line north 17½° west, magnetic, from the zero of the abutment, and finally to the recommendation that this direction be given to the pier.

From station A, (accompanying diagram,) 1,200 feet from the abutment on the line north 12½° east, magnetic, a line was sounded toward the outer end of the railroad-pier, and an examination of the bottom was made with the following results:

Station.	Distance from station A.	Depth of water, mean low stage.	Pressure applied.	Depth obtained.
	Feet.	*Feet.*		*Feet.*
B	410	14.5	One man shoving and jerking	6½
C	968	17.5	Weight of six men	13½
D	1,048	16.0	ditto	6 1-6
E	1,253	16.0	ditto	7½
F	1,640	14.0	ditto	6½

At station B the rod used was 2 inches square white pine; at the other points a hollow iron drill of 2 inches external diameter was taken.

As the sustaining-capacity of the bottom seemed to increase toward the railroad-pier, tests were made along three new lines, the zero of the abutment being one point of each line all on the west side of the axis north 12½° east, magnetic. The magnetic bearings of these lines and the results obtained are given below.

The drill used was that described above. The auger was of 1 inch square steel turned in a spiral of 3½ inches diameter on the lower end; the pipe was 4 inches internal diameter.

Line north 6½° west, magnetic.

Station.	Distance from zero of abutment.	Depth of water, mean low stage.	Instrument used.	Pressure applied.	Depth attained.	Nature of strata.	Remarks.
	Feet.	*Feet.*			*Feet.*		
B	1,274	15.5	Pine rod.	1 man shoving and jerking.	6½	Mud	Took 2 men to withdraw it.
	1,274	15.5	Auger	Lever-boring	9	Sand and little mud	Drew up to insert pipe.
			Pipe	Artesian boring.	0 to 6½	6½ feet black mud and little sand.	
					6½ to 11	4½ feet sand and black mud.	
					11 to 20	9 feet sand and black mud.	
					20 to 23	3 feet sand, shell, and little mud.	Compelled by weather to desist.
G	1,474	20.5	Auger	Weight of 5 men.	18	Mud.	
				4 men boring	23	Reached hard sand.	
					25	Hard sand and shell	Reversed 1 foot before it would draw.
H	1,674	22.7	Auger	Weight of 2 men.	12½	Mud.	
				Weight of 4 men.	16½	Mud.	
				4 men boring	22	Struck sand.	
				4 men boring, (hand.)	24	Sand and shell	Reversed 7 inches.

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Line north 11¼° west, magnetic.

Stations.	Distance in feet from zero of abutment.	Depth of water.	Instrument used.	Pressure applied.	Depth attained.	Nature of strata.	Remarks.
	Feet.	*Feet.*			*Feet.*		
I...	1,390	15.7	Drill	Weight of 6 men.	8¼		
J ..	1,544	20.0	Drill	Weight of 6 men.	14½		
K..	1,600	21.0	Pipe	Artesian boring.	0 to 12.....	12 soft, black mud and little fine sand.	
					12 to 15....	3 soft, blue mud and little fine sand.	
					15 to 17....	2 sand, shell, and little blue mud.	
					17 to 21½...	4½ soft, blue mud, some sand.	
					21½ to 25...	3½ solid sand and gravel.	Same strata as lowest depths of line north 12½° east.
					25 to 26½...	.....	Auger within pipe would penetrate no farther.
L..	1,772	22.2	Drill	Weight of 5 men.	12		

Line north 17¾° west, magnetic.

Station.	Distance in feet from zero of abutment.	Depth of water.	Instrument used.	Pressure applied.	Depth attained.	Nature of strata.	Remarks.
	Feet.	*Feet.*			*Feet.*		
M..	1,100	6.7	Auger ..	4 men boring..	11	Solid bar sand colored with mud.	Could penetrate no farther.
N..	1,200	12.3	Auger ..	Weight of 6 men.	1		
				4 men boring..	12	Sand.....	Driven away by wind.
O..	1,300	16.3	Pipe	Artesian boring.	0 to 6.....	6 soft, black mud.	
					6 to 14.....	8 blue mud and little sand.	
					14 to 21....	7 sand, shell, and few pebbles.	
					21 to 25....	4 blue mud and little shell.	
					25 to 25 5-6.	5-6 sand and gravel.	
P..	1,400	18.7	Pipe	Artesian boring.	0 to 8.....	Soft, black mud.	
					8 to 12½....	Black mud and little sand.	
					12½ to 19...	Sand, shell, and little mud.	
					19 to 22....	Blue mud and sand.	
					22	Gravel and sand.	
Q..	1,600	21.2	Pipe	Artesian boring.	0 to 12.....	12 soft, black mud and fine sand.	
					12 to 15....	3 sand and some blue mud and shell.	
					15 to 17....	2 sand, shell, pebbles, and mud.	
					17 to 21½...	4½ blue mud, shell, and some sand.	
					21½ to 22½..	1 sand and gravel.	
R..	1,700	21.3	Pipe	Artesian borings.	0 to 8.....	8 soft, black mud.	
					8 to 12.....	4 firmer blue mud and little sand.	
					12 to 16½...	4½ sand and shell.	
					16½ to 21...	4½ stiff blue mud and some sand and shell. Struck gravel and sand.	
S...	1,717	24.8	Drill	Its own weight	7½	Soft mud.	
				Weight, 4 men.	10½	Mud.	
T..	1,800	21.4	Drill	Weight, 6 men.	13		
			Auger ..	Weight, 6 men.	10		
				4 men boring..	22½	Struck gravel.....	8 men and double tackle to draw it.

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Line north 11¼° west, magnetic.

Stations.	Distance in feet from zero of abutment.	Depth of water.	Instrument used.	Pressure applied.	Depth attained.	Nature of strata.	Remarks.
	Feet.	*Feet.*			*Feet.*		
I...	1,390	15.7	Drill	Weight of 6 men.	8¼		
J ..	1,544	20.0	Drill	Weight of 6 men.	14½		
K..	1,600	21.0	Pipe	Artesian boring.	0 to 12.....	12 soft, black mud and little fine sand.	
					12 to 15....	3 soft, blue mud and little fine sand.	
					15 to 17....	2 sand, shell, and little blue mud.	
					17 to 21½...	4½ soft, blue mud, some sand.	
					21½ to 25...	3½ solid sand and gravel.	Same strata as lowest depths of line north 12½° east.
					25 to 26½...	.....	Auger within pipe would penetrate no farther.
L ..	1,772	22.2	Drill	Weight of 5 men.	12		

Line north 17½° west, magnetic.

Station.	Distance in feet from zero of abutment.	Depth of water.	Instrument used.	Pressure applied.	Depth attained.	Nature of strata.	Remarks.
	Feet.	*Feet.*			*Feet.*		
M..	1,100	6.7	Auger ..	4 men boring..	11	Solid bar sand colored with mud.	Could penetrate no farther.
N..	1,200	12.3	Auger ..	Weight of 6 men.	1		
				4 men boring..	12	Sand.....	Driven away by wind.
O..	1,300	16.3	Pipe	Artesian boring.	0 to 6.....	6 soft, black mud.	
					6 to 14.....	8 blue mud and little sand.	
					14 to 21....	7 sand, shell, and few pebbles.	
					21 to 25....	4 blue mud and little shell.	
					25 to 25 5-6.	5-6 sand and gravel.	
P ..	1,400	18.7	Pipe	Artesian boring.	0 to 8.....	Soft, black mud.	
					8 to 12½....	Black mud and little sand.	
					12½ to 19...	Sand, shell, and little mud.	
					19 to 22....	Blue mud and sand.	
					22	Gravel and sand.	
Q..	1,600	21.2	Pipe	Artesian boring.	0 to 12.....	12 soft, black mud and fine sand.	
					12 to 15....	3 sand and some blue mud and shell.	
					15 to 17....	2 sand, shell, pebbles, and mud.	
					17 to 21½...	4½ blue mud, shell, and some sand.	
					21½ to 22½..	1 sand and gravel.	
R..	1,700	21.3	Pipe	Artesian borings.	0 to 8.....	8 soft, black mud.	
					8 to 12.....	4 firmer blue mud and little sand.	
					12 to 16½...	4½ sand and shell.	
					16½ to 21...	4½ stiff blue mud and some sand and shell. Struck gravel and sand.	
S...	1,717	24.8	Drill	Its own weight	7½	Soft mud.	
				Weight, 4 men.	10½	Mud.	
T..	1,800	21.4	Drill	Weight, 6 men.	13		
			Auger ..	Weight, 6 men.	10		
				4 men boring..	22½	Struck gravel.....	8 men and double tackle to draw it.

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APPENDIX B.

Statement showing the proportions and nature of the sand contained in the strata (to ascertain depths) constituting the bed of the harbor formed by the Delaware Breakwater at three stations; No. 1 being 1,340, and No. 2, 1,640 feet horizontal measurement from low-water mark, on a line bearing north 17½° west, magnetic, from the center of the abutment of the proposed iron landing-pier, and No. 3 being 1,350 feet from low-water mark, on a line bearing north 12½° east, magnetic, from the center above designated.

At station No. 1, 1,340 *feet from low-water mark, line north* 17½° *west, magnetic.*

Thickness of stratum.	Percentage of sand by weight.	Fine or coarse.	Color.	Purely silliceous or not.	Remarks.
From 0 to 8 feet..	30	Exceedingly fine ..	Slate	No ..	
From 8 to 12½ feet..	30	.....do.....	....do....	..do..	Containing some coarse sand.
From 12½ to 19 feet..	80	Medium.....	Light ...	Yes .	Contains little gravel and sand; comminuted shell.
From 19 to 22 feet...	30	.....do.....	....do....	..do..	
At 22 feet.....	.....	.....	.....	.....	Purely gravel and sand.

At station No. 2, 1,640 *feet from low-water mark, line north* 17½° *west, magnetic.*

Thickness of stratum.	Percentage of sand by weight.	Fine or coarse.	Color.	Purely silliceous or not.	Remarks.
From 0 to 8 feet..	20	Exceedingly fine ..	Light ...	Yes .	Contains a trace of shell.
From 8 to 12 feet..	37	.....do.....	....do....	..do..	Do.
From 12 to 16½ feet..	92	Coarse	....do....	..do..	Contains pebbles and shell.
From 16½ to 18½ feet..	40	Exceedingly fine ..	....do....	..do..	Contains small pebbles.
From 18½ to 21 feet..	75	Coarse	....do....	..do..	Do.
At 21 feet.....	.....	.....	.....	.....	Unmixed sand, gravel, and stones.

At station No. 3, 1,350 *feet from low-water mark, line north* 12½° *east, magnetic.*

Thickness of stratum.	Percentage of sand by weight.	Fine or coarse.	Color.	Purely silliceous or not.	Remarks.
From 0 to 5 feet..	90	Very fine.....	White ..	Yes .	
From 5 to 14 feet..	25	Exceedingly fine ..	Slate	No ..	
From 14 to 23 feet..	45	.....do.....	....do....	..do..	
From 23 to 33½ feet..	15	½ exceedingly fine..	....do....	..do..	
		½ medium.....	Light ash	Yes .	
From 33½ to 35½ feet..	75	Fine.....	.....	..do..	Contains gravel-stones about the size of a bean.
From 35½ to 38 feet..	0	Pure	Mud	.....	
From 38 to 40 feet..	5	Fine.....	Light ...	Yes .	
At 40 feet.....	.....	.....	.....	.....	Only sand and gravel, very fine.

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Table showing the proportions and nature of the sand contained in the strata (to certain depths) constituting the bed of the harbor formed by the Delaware Breakwater on the line north 17½° west, magnetic from the center of the abutment of the proposed iron landing-pier. (The stations are distinguished by their horizontal distances in feet from the zero-point at the center above designated.)

Station.	Thickness of stratum.	Percentage of sand by weight.	Fine or coarse.	Color.	Purely siliceous or not.	Other insoluble material besides the sand.
570	0 to 5½ feet	100	Very fine	Light yellow	Yes.	
	5½ to 6½ feet	100	....do	Gray	..do.	Pebbles, size of bean, and larger.
	6½ to 21⅛ feet	100	Fine	White	..do.	A few pebbles, size of buck-shot.
	21⅛ to 28 feet	91	....do	... do	..do.	
	28 to 31½ feet	30	Very fine	Light slate	..do.	A trace of comminuted shell.
	31½ to 38½ feet	91	Medium	Silvery slate	..do.	Fragments of shells and a few small pebbles.
	38½ to 39½ feet	92	....do	....do	..do.	Pebbles size of a bean and comminuted shell.
	39½ to 43 feet	87	Coarser	....do	..do.	Comminuted shell.
910	0 to 20 feet	96	Medium	White	..do.	
	20 to 23 5-6 feet	92	....do	....do	..do.	
	23 5-6 to 27 5-6 feet	57	....do	....do	..do.	
	27 5-6 to 29 5-6 feet	53	Coarse	Gray	..do.	Comminuted shell.
	29 5-6 to 35 5-6 feet	90	....do	....do	..do.	Comminuted shell, sand coarse.
	35 5-6 to 37½ feet	92	Very coarse	Darker gray	..do.	Comminuted shell and pebbles.
1155	0 to 8½ feet	94	Very fine	White	..do.	Size of buck-shot; trace of shell.
	8½ to 17 feet	95	....do	....do	..do.	Do.
	17 to 23 feet	73	....do	....do	..do.	Do.
	23 to 30 feet	72	Medium	Slate	..do.	Small pebbles and shells.
	30 to 33 feet	33	Fine	....do	..do.	Principally gravel and comminuted shell.
1166	0 to 9 feet	100				
	9 to 15½ feet	93	Very fine	Yellowish gray	Yes.	
	15½ to 17 feet	60	....do	Silver gray	..do.	Trace of comminuted shell.
	17 to 22 feet	80	....do	White	..do.	Do.
	22 to 25½ feet	90	Fine and coarse mixed.	Gray	..do.	Larger fragments of shell.
	25½ to 26 feet	85	Fine	Slate	..do.	Principally coarse gravel.
	26 to 30¼ feet	22	....do	....do	..do.	Principally fine gravel and shell.
	30¼ to 31¼ feet				..do.	
1176	0 to 3½ feet	97	Very fine	Light yellow	..do.	
	3½ to 7 feet	89	....do	Yellowish white	..do.	
	7 to 21½ feet	90	A little coarser	White	..do.	Few pebbles, size buck-shot.
	21½ to 24 feet	92	Medium	Gray	..do.	Comminuted shell.
1191	0 to 7 feet	36	Very fine	Light yellow	..do.	Do.
1201	0 to 2 feet	98	....do	....do	..do.	
1218	0 to 3 feet	89	....do	Yellow white	..do.	
	3 to 8½ feet	38	....do	Slate	..do.	Trace of shell.
	8½ to 15 feet	92	....do	White	..do.	
	15 to 18 feet	49	....do	....do	..do.	Trace of shell.
	18 to 24 feet	92	Fine	Gray	..do.	Do.
	24 to 26½ feet	93	Medium	Dark slate	..do.	Comminuted shell and pebbles.
	26½ to 28 11-12 feet	21	....do	Gray	..do.	Comminuted shell with more pebbles.
	28 11-12 to 30 1-6 feet	100	Coarse	....do	..do.	Gravel.
1241	0 to 6½ feet	20	Very fine	Light yellow	..do.	Fragments of shell.
	6½ to 10½ feet	83	....do	Yellow white	..do.	
	10½ to 14½ feet	58	....do	....do	..do.	
	14½ to 20 feet	66	....do	White	..do.	
	20 to 23½ feet	92	Coarse	Gray	..do.	Fragments of shell and few fine pebbles.
	23½ to 27½ feet	25	Very fine	Slate	..do.	Pebbles, size of buck-shot, and comminuted shell.
1250	0 to 7 feet	22	....do	Yellowish brown	..do.	
	7 to 13 feet	47	Fine	White	..do.	Trace of shell.
	13 to 20 feet	78	Medium	Gray	..do.	Comminuted shell.
	20 to 23 feet	76	Fine	....do	..do.	Pebbles and fragments of shell.

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Station.	Thickness of stratum.	Percentage of sand by weight.	Fine or coarse.	Color.	Purely siliceous or not.	Other insoluble material besides the sand.
	23 to 25 feet	26	Very fine	do	do	Half pebbles and shell.
	25 to 26 feet	100	Coarse	do	do	Gravel.
1300	0 to 6 feet	28	Very fine	Yellowish brown	do	Scattering pebbles.
	6 to 14 feet	43	do	Brown	do	
	14 to 21 feet	90	do	Gray	do	Pebbles and broken shell.
	21 to 25 feet	28	Medium	White	do	Small pebbles and comminuted shell.
	25 to 25 5-6 ft.	100	Coarse	do	do	Coarse sand gravel.
1400	0 to 8 feet	31				Trace of shell.
	8 to 12½ feet	43				Shell.
	12½ to 19 feet	81				Shell and gravel.
	19 to 20½ feet	31				Do.
1500	0 to 11 feet	20	Very fine	Yellowish brown	Yes	
	11 to 17½ feet	86	Medium	Gray	do	Pebbles and fragments of shell.
	17½ to 18½ feet	30	do	White	do	Pebbles and comminuted shell.
1600	0 to 12 feet	20	Exceedingly fine	Yellowish brown	do	Trace of shell.
	12 to 15 feet	80	Mixture of coarse and medium.	Silver gray	do	Fragments of shell.
	15 to 17 feet	83	do	Gray	do	Pebbles and fragments of shell.
	17 to 21½ feet	35	Fine	Slate	do	Comminuted shell and small pebbles.
	21½ to 22½ feet	100	Coarse	Gray	do	Gravel.
1700	0 to 8 feet	20				Trace of shell.
	8 to 12 feet	37				Do.
	12 to 16½ feet	92				Shell and pebbles.
	16½ to 18½ feet	41				Do.
	18½ to 21 feet	75				Do.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 3, 1872.

COLONEL: Your letter of December 26th calling attention of the Chief of Engineers to an error in statement in a communication of J. S. Gibbons, president Junction and Breakwater Railroad, attached to the report of a board of engineers, upon the pier at Lewes, Delaware, and printed in the annual report of the Chief of Engineers, 1871, has been received.

Your views in regard to closing the gap in the Delaware Breakwater are on file in this office, and are quite well understood by the Chief of Engineers, but in order that the statement of Mr. Gibbons may not mislead others, your letter will be placed on file with a view to its publication in the annual report for the present fiscal year.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers.

Colonel HARTMAN BACHE,
Corps of Engineers, Retired, Philadelphia, Pennsylvania.

PHILADELPHIA, *December* 26, 1871.

GENERAL: A communication from Mr. J. J. Gibbons, president of the Junction and Breakwater Railroad Company, dated June 19, 1871, Appendix R 6, marked A, in the proceedings of the board of engineers,

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to consider and report upon the plan for a pier at Lewes, Delaware, (see report of the Chief of Engineers for 1871, page 682,) contains the following statement under the 8th head, which, as it is incorrect as far as I am concerned, I desire to call the attention of the office: "8th. * * * It may be assumed that Congress will cause the upper gap [of the Delaware Breakwater] to be closed at no distant period, in accordance with the advice of all the United States engineers who have successively been stationed at this post for many years past."

The Delaware Breakwater was projected about forty-two years ago, and I was in charge of it from 1839 to 1853, or about one-third of the time, and from first to last opposed to closing the gap, for reasons I still consider unanswerable. For this opinion and for these reasons I appeal to my communications to the Bureau of Topographical Engineers, between the years named, and particularly to those of September 16, 1839, and October 15, 1844.

Very respectfully, your obedient servant,

HARTMAN BACHE,
Colonel of Engineers, Brevet Brigadier-General, Retired.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

R 5.

IMPROVING HARBOR AT MARCUS HOOK, PENNSYLVANIA.

After the completion of the four ice-piers in this harbor last season an iron ladder was attached to each pier to assist sailors in gaining access to the top of the piers during the season of running ice. The ladders were placed in position the early part of last winter, against the most sheltered face of each pier, but were found to be insufficient to withstand the force of the heavy fields of ice that came into the harbor. It is proposed to substitute ladders, to be fastened into a recess that will be cut into the stone-work of each pier. This will be done before the winter sets in.

Statement of funds.

Amount available July 1, 1871	$15,914 69
Expenditures for year ending June 30, 1872	4,782 80
Available for year ending June 30, 1873	11,131 89

R 6.

IMPROVEMENT OF WILMINGTON HARBOR, DELAWARE.

The balance of the appropriation available for the improvement of this harbor, at the commencement of the fiscal year, was applied to the removal of about 14,000 cubic yards of dredged material, and of a small fast rock situated in mid-channel, and containing about 28 cubic yards. This being accomplished, work was suspended on the 3d August, 1871.

The expenditure of the appropriation of July 11, 1870, of $15,000, for the improvement of this harbor, has resulted in increasing the depth of water along the channel-way at the mouth of the river, through the bar

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into the Delaware, along the channel-way above the mouth for a distance of nearly 2,000 feet, also along the north side of channel-way above Third street for a distance of 1,500 feet. About 39,000 cubic yards of sand and mud have been dredged from the channel at these different localities, and 28 cubic yards of rock have been removed by blasting. This rock was situated on the south side of the channel, about 600 feet above Third street bridge, and at ordinary low water had about 8 feet of water upon it. It was a serious obstruction to the navigation of the river, which generally afforded 10 to 11 feet of water.

Additional dredging is required at several points in the harbor, and a small ledge of rocks should be removed from the bed of the river in the vicinity of the work done last season, and some, also, at a point just below Third street bridge.

It is proposed during the present season to remove by dredging about 5,000 cubic yards of mud from the channel-way of the river in the vicinity of mouth of Brandywine Creek; 10,000 cubic yards of mud from the channel-way of the river between Third and Market streets; 4,000 cubic yards of sand and loose material from the channel-way of the river above Market street, and about 35 cubic yards of rock from the channel-way of the river near Third street bridge.

To remove the rock from the south side of channel-way below and adjacent to Third street bridge, mentioned above, and complete the improvement of Wilmington Harbor, will require an appropriation of $6,000, which is recommended to be made for the next year.

Population of Wilmington, Delaware, 35,000; present annual increase, about 2,000. Number of vessels registered at this port, ——; tonnage of same, ——.

The amount of capital employed in manufactures in the city of Wilmington and its immediate vicinity is $11,757,500; value of manufactured articles, $18,520,275.

Wilmington is in the collection-district of Delaware, and is a port of entry; light-house and fort are respectively Christiana Light and Fort Delaware.

The amount of revenue collected at Wilmington during the fiscal year ending June 30, 1872, is $42,520.77, and at Philadelphia, Pennsylvania, $8,533,570.17.

Statement of funds.

Amount available July 1, 1871	$6,280 63
Expended since July 1, 1871, for dredging, removal of rock, &c	6,280 63
Appropriated by act approved June 10, 1872	10,000 00
Available for year ending June 30, 1873	10,000 00
Appropriation asked for year ending June 30, 1874	6,000 00

R 7.

REPAIR OF PIER OF THE ICE-HARBOR AT NEW CASTLE, DELAWARE, AND FOR BUILDING NEW PIER AT SAID HARBOR.

Last year's appropriation was applied prior to the 1st July, 1871.

Advertisements will be issued calling for proposals for the application of this year's appropriation of $27,000 to the construction of the work. It is proposed to remove from the harbor an old pier which was never finished, and which is not placed in relation to the other piers of the ice-harbor; to complete the repairs which were begun last year on another pier, and to construct as far as practicable one of the new piers

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required to adapt the harbor to the present needs of the winter navigation of the Delaware.

To continue the works, which include three ice-piers, an appropriation is asked for the next fiscal year; and it is recommended that, in addition, so much of the balance of $11,131.89 now remaining of the appropriation made for the harbor at Marcus Hook, Pennsylvania, as may not be needed for that work, be re-appropriated for the ice-harbor at New Castle.

New Castle is in the collection-district of Wilmington, Delaware. Fort Delaware is the nearest fort, and Christiana Light the nearest light-house.

The revenue collected at Wilmington during year 1871-'72 amounted to $42,520.77, and at Philadelphia $8,533,570.17.

Statement of funds.

Appropriated by act of June 10, 1872	$27,000
Expended to June 30, 1872	
Available for year ending July 30, 1873	27,000
Appropriation asked for year ending June 30, 1874	$50,000

And that so much of the balance remaining unexpended of the appropriation for "Improving harbor at Marcus Hook, Pennsylvania," as may not be needed there, be, and is hereby, appropriated to the ice-harbor piers at New Castle Harbor, Delaware.

R 8.

CLEARING AND IMPROVING THE CHANNEL OF THE SCHUYLKILL RIVER, PENNSYLVANIA.

Under act of March 3, 1871, $10,000 was appropriated for the improvement of this river. A portion of this amount was expended in equalizing the width and depth of the cut at the mouth by the removal of several lumps and projecting points, caused by winter ice and drift action. The tendency of the point reaching south from League Island was to extend itself across the outer end of the cut, the material being soft blue mud, which, when wet, will only maintain itself on a slope nearly level. The widening of the cut on the down-river side will lessen this difficulty in the future.

The channel near the petroleum wharves at Point Breeze was widened by the removal of a hard gravelly point, projecting into it, and which was greatly in the way of vessels passing up and down the river. The balance of the appropriation was expended upon the cuts at Gibson's Point.

The appropriation of $40,000, made by act of June 10, 1872, will be applied in widening and deepening the cut at the mouth, in connecting the 18-foot channel above Penrose Ferry, now disconnected by ridges of sand and gravel, (said to have been produced by the receding waters of a freshet, which flowed into the river from a break in the meadow-banks at this place;) in continuing and completing the cut through the shoal near Gibson's Point; in removing the rock extending into the channel near Locust street; and in connecting the 18-foot channels wherever necessary between Gibson's Point and Chestnut street bridge.

It is proposed to continue the improvement of this river during the next fiscal year by widening the entrance and deepening it to 20 feet, and carrying this depth up to the Point Breeze and Gibson Point

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wharves. This is the locality of extensive shipments of petroleum, which are made in the largest vessels frequenting the port of Philadelphia. From Gibson's Point up to Chestnut street bridge, a depth of 18 feet is sufficient, and this agrees with the natural water-way of the river. This upper section is the seat of commerce in foreign marble, coal, iron, &c., which is carried on in barks, brigs, and ships.

Statement of funds.

Available July 1, 1871	$9,903 25
Appropriation by act of June 10, 1872	40,000 00
	49,903 25
Expended	9,903 25
Available for year ending June 30, 1873	40,000 00
Appropriation asked for year ending June 30, 1874	$40,000 00

R 9.

IMPROVEMENT OF SOUTH RIVER, NEW JERSEY.

Work was commenced on this improvement after some delay, caused by straw-bidding, by dredging at the lower end of the canal connecting the South and the Raritan Rivers. The dredged material was placed on the banks of the canal. The excavation was carried nearly half way through the canal when operations were suspended by the closing of the season. The sand placed on the banks being of a good quality and of value to builders, and permission to deposit it having been given by the owners of the land forming the sides of the canal, no difficulty was apprehended in having it removed, as it was sought after and a number of boat-loads taken away.

Some of the land-owners observing that the sand was being removed rapidly, demanded a considerable price per load, which had the effect of driving the vessels away. This resulted in a suit, which being dismissed by the justice, boats again felt safe in removing the sand. A careful survey was made in the spring of 1872, which showed that no unfavorable action had taken place other than the natural wash of the quicksand from the sides of the cut, and a little shoaling at the entrance to the Raritan River, where the ebb currents of the canal meet those of the river. A short wing-dam at this point would lead the ebb current of the canal at a small angle with that in the river. A pile protection may also be found necessary on the sides of the canal at the shoalest and widest place, the material of bank being quicksand, and liable to slide into the cut.

It is proposed to expend the remainder of the appropriation in extending the cuts through the canal, so as to make it navigable at low water through its entire length, which will effect a saving in distance of four miles over the route by the river.

To remedy the action of the quicksand shoaling up, or restrain it by sheathing pile work, a small appropriation is asked.

Statement of funds.

Appropriation by act of March 3, 1871	$15,000 00
Expended to June 30, 1872	10,113 32
	4,886 68
Appropriation asked for year ending June 30, 1874	$5,000 00

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R 10.

IMPROVEMENT OF THE NORTH AND SOUTH BRANCHES OF SHREWSBURY RIVER, NEW JERSEY.

Authority having been given by letter from the Chief of Engineers under date June 20, 1871, work was at once commenced on the improvement of this river. A passage was first dredged through the bulk-head separating the channel of the South Shrewsbury River from that of the north. On the completion of this work, two cuts were carried through the bulk-head at the entrance of the river, from Sandy Hook Bay; the great extent of this bulk-head necessitated the removal of a large body of sand, and from its exposed situation it was found inadvisable to continue working at this place after the season became far advanced. The dredging-machinery was therefore moved up the river to Rocky Point, and the improvement of the channel at this locality (being the mouth of the North Shrewsbury) commenced. At this place the river makes a short turn from south to west and the old channel follows close under the Point, making the navigation very crooked. The shifting nature of the sand-bars here rendered it advantageous to adopt the longer channel, which curves gently and follows the convex side of the river. The obstructions to this channel consisted of a bulk head at each end: a passage was dredged through each of these, and several lumps along the channel were removed, making a good channel and one not likely to deteriorate. Winter prevented any other operations. On the resumption of work in the spring of 1872, an examination was made of the several dredged localities, and the action of the currents noted. The result proved better than was hoped for. The channel leading into the South Shrewsbury River had deepened somewhat and maintained about the width dredged. The Rocky Point Channel had deepened in several places, and the scoured material was deposited at the upper end, which required some work to render the locality navigable at low water. The cuts at the mouth of the river, near Sandy Hook Bay, had shoaled by the material washing from the sides of the cut. After removing the shoal in the Rocky Point passage, a channel was dredged through the shoals at Jumping Point, South Shrewsbury River; on the completion of which the dredge was again moved to the mouth of the river, and the deepening of the cuts, before made, commenced. This is now being carried forward rapidly and will soon be completed. In order to give a trumpet shape to the upper entrance to the Rocky Point Channel (described above) and to the main entrance from Sandy Hook Bay, and to clear the Jumping Point cut (by which freighters pass up to Long Branch, Ocean Port, &c.) from the effects of a cross current, a small appropriation is needed.

Statement of funds.

Appropriation by act of March 3, 1871	$14,000 00
Expended to June 30, 1872	9,368 01
Amount available July 1, 1872	4,631 99
Appropriation asked for year ending June 30, 1874	$5,000 00

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R 11.

IMPROVEMENT OF DELAWARE RIVER BETWEEN TRENTON AND BORDENTOWN, NEW JERSEY.

Advertisements of the work to be done will be published and a contract entered into for the application of the appropriation of $10,000 to this improvement. This sum is too small to effect any result that will be of service to this navigation. If the sum of $30,000 be appropriated for the next year, it will enable a partial channel-way to be excavated through the shoals, which impede the passage of steamers, vessels, and lumber-rafts, between Trenton and Philadelphia.

Trenton is in the collection-district of Burlington; the nearest port of entry is Philadelphia; light-house and fort are respectively Fort Mifflin Light, and Fort Mifflin.

Statement of funds.

Appropriated by act of June 10, 1872	$10,000 00
Expended to June 30, 1872	
	10,000 00
Appropriation asked for year ending June 30, 1874	$30,000 00

R 12.

SURVEY OF HORSESHOE SHOALS, DELAWARE RIVER, PENNSYLVANIA.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pennsylvania, June 17, 1872.

GENERAL: In the third section of the act making appropriations for rivers and harbors, approved March 3, 1871, (General Nature, No. 50,) provision is made "for the survey of Horseshoe Shoals in the Delaware River, below Philadelphia, Pennsylvania," and by your instructions of March 21, 1871, the work was placed in my charge for execution.

The object designed by the law was, no doubt, to have a careful examination made of the difficulties attending the winter navigation of this part of the Delaware River, and to obtain practical suggestions and plans for such relief as can be provided in the case.

I have the honor to make the following report upon the examination made of the river, and to present the accompanying projects for the improvement of the navigation of the Horseshoe region during the ice season.

The Delaware River being, at Philadelphia, in latitude nearly 40°, is subject to more or less obstruction by ice from winter to winter. From Burlington down to Philadelphia the course of the river is about southwest, tolerably straight, and increasing gradually in width from a third to a half or five-eighths of a mile. From Port Mifflin to New Castle, or Delaware City, the course is about the same, with no material change of direction, and the width increasing gradually from a mile to two miles and over. Below Delaware City the breadth rapidly increases, and the river soon becomes a bay.

Between Philadelphia and Fort Mifflin occurs the marked bend called the *Horseshoe*. The river here changes its course from southwest to east of south, to south, southwest, and west in a distance of some six miles. It is within the length of four or five miles here that the serious

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difficulties of the winter navigation during the season of running ice are encountered. The past winter has afforded a very good example of these difficulties. The temperature has not been of exceptional severity, but the first freeze occurred early in December, (15° on 5th December,) since when, in January and February, there was no period of sufficient warmth to melt the ice, which continued to embarrass navigation until after the middle of March.

Among the first questions presenting themselves in regard to these difficulties are whether they existed in past years as they do now, or whether they are of late development, and whether they are increasing or diminishing. The means of examining these questions have been afforded me by Messrs. J. M. Ellis & Sons, through whose courtesy I have had the opportunity of consulting the records of temperature of Philadelphia for eighty years past, and of collating the notes of the condition of the Delaware, made during the winters of this period by Messrs. Charles Pierce and J. M. Ellis, the value of whose observations is well known in Philadelphia. The notes of winter temperatures, and the corresponding condition of the Horseshoe with explanatory diagrams will be found in Appendix A attached to this report. An examination of the notes, tables, and diagrams will show that there is no reason to consider that the relation between the temperature of the winter and the periods of closed river has undergone any sensible change.

The average winter temperature for twenty years from 1790 to 1810 is 30°.3; the average period of closed river is 15.95 days. Average winter temperature from 1810 to 1830 is 30°.33; average period of closed river is 9.85 days. Average winter temperature from 1830 and to 1850 is 31°.31; average period of closed river is 11 days. Average winter temperature from 1850 to 1860 is 34°.07; average period of closed river is 9.7 days. The use of the ice-boats prevented the periods of closed river for the ten years, (1860–70,) from being noted.

Another question of importance in the history of this subject is the condition of the water-way of the river during past years, whether it has changed, and in what respects. I am indebted to Strickland Kneas, esq., late chief engineer and surveyor of the city, for the use of two surveys of the river from the files of his office, one made in 1819, by David McClure, and the other by the city government of Philadelphia in 1854–'56 and 1864–'66. A comparison of these surveys with that made by the United States Coast Survey in 1842 and 1843, and with the one executed last summer under my direction, affords very fair *data* for the discussion of this question. The comparative chart of surveys which accompanies this report exhibits these surveys platted, together with a series of cross-sections at intervals of about half a mile up and down the river. An examination of this map shows that the river-bed has remained essentially unchanged during the fifty and more years embraced by the surveys. On some of the sections an oscillatory action within moderate limits appears; that is, the lines of 1819 and 1871 accord more nearly with each other than with the intermediate ones. The back channel (behind League Island) has been gradually filling up, and the effect of this is shown on the section H—H′, where a deposit appears to be in progress on the Pennsylvania shore at the head of that channel. The only special shoal is shown on sections H′—H″ and I′—I″, on the Pennsylvania side. This is due largely to the sinking of the frigate Ironsides, which took place in 1866, at the spot shown on the charts. With these exceptions, no noteworthy change in the water-way, or in the Horseshoe Shoal, is indicated. The river appears to have attained a stable regimen in the region under consideration.

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While the ice obstructions of the Delaware are much the greatest in the Horseshoe region, it will be borne in mind that they exist to some extent in the river below, as is the case in like latitudes elsewhere. Vessels encounter the ice at times below Chester, at New Castle, and down to Reedy Island. But the river is constantly widening, its course is southwardly, and the influence of the sea-water softens the ice. Sufficient details on this point are given in Appendix B. Twice, during the last winter, the Breakwater Harbor, at the mouth of the bay, was filled with ice; once from the river above, and once by the freezing over of the harbor itself. These unusual occurrences illustrate the persistency of low temperature during the season.

The chart of the survey shows that the water-way of the river, as it approaches the Horseshoe bend, is of sufficient dimensions, (with the exception, perhaps, of the projection at Kaighn's Point,) until the region is reached between Gloucester and Greenwich, which is defined by the Petroleum and Greenwich Point wharves on the Pennsylvania side, and the Print Works, and Gloucester Point wharves on the New Jersey side. Here there is a manifest contraction, which is greatest between Greenwich Point and Gloucester Point, just where the river passes into the Horseshoe Bend proper. As soon as this line is passed, the river widens rapidly into a lake-like expanse, extending down to Eagle Point and the upper part of League Island. This surface is about 10,000 feet by 7,500. The width of the water-way at Greenwich Point barely exceeds 2,000 feet.

In the Horseshoe, the channel sweeps round with a regular curve on the Jersey side, while the shoal is found on the Pennsylvania or convex shore, where it occupies just about half the width of the river.

The currents show no material abnormal character. The flood currents at the upper end of the bend exhibit some divergence and a general direction toward the Jersey shore, oblique to the contour lines of the bottom. Along the shoal toward the head of League Island their course is very direct and the velocity unimpaired.

While the several courses of investigation now described, namely, of meteorology, water-way, and currents, all lead to the conclusion that the regimen of the river is practically settled and stable; yet, in order to clear one other point in the actual origin and composition of the great shoal of the Horseshoe, two borings were made into its substance at the points shown on the maps to about the depth of the river-bottom, and samples of its material were drawn up and have been preserved. These borings confirm the other kinds of evidence examined, and show that the shoal is not derived from the neighboring shores, nor the result of causes now active, but that its mineral constituents are similar to those of League Island, or the river-bed generally, and that it is not of recent formation, but must be referred to a prior historical date. (See Appendix B 1.)

Projects for remedying the difficulties of the navigation may therefore be based upon the *datum* of a stable river, affording no promise of changes likely either to injure or facilitate the artificial structures or devices of the engineer.

No great difficulties are encountered from the ice on the ebb-tides. There is sufficient width to the river to enable it to pass down without serious jamming, and if ascending vessels are pressed they can take refuge in the ice harbors at Marcus Hook, New Castle, &c.

When the tide turns to flood the embarrassments begin, and increase as the river is ascended and the current runs freely. The final closing of the channel takes place in the latter part of the flood, and above the

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Horseshoe buoy, up toward the gorge at Gloucester and Greenwich Points. Of course particular winds may cause exceptions to this rule, but it is the general one as ascertained by conversations with the masters of the ice and tug-boats, steamships, and others interested in this subject.

The common winter winds are from the north, northwest, and northeast. The chart shows that a northeast wind would blow down the river, and clear the ice out. North and northwest winds tend to pack it on the Jersey shore where the channel is. These views are confirmed by the observations made at Fort Mifflin. (See Appendix C.)

It is evident that the large surface area of the Horseshoe region must itself produce a great deal of ice; and, moreover, as soon as the flood-tide passes Eagle Point and the head of League Island, the ice which it is bringing up will be pushed laterally out of the current upon the flats of Ladds and Timber Creek coves, the back channel and Horseshoe Shoal. This mass will move up the river with diminished velocity until its progress is checked by the oblique shore below Gloucester Point, and by the general and rapid narrowing of the surface of the water-way. The final closing of the channel-passage at the locality stated above must follow as a general rule.

In looking for remedies for this state of things it is evident that all remedial measures can be classed under these heads:

First. Breaking up the ice, and removing it by active machinery.

Second. Meliorative treatment of the locality by works of construction, and by improvement of the water-way.

Third. Avoidance of the obstructed part of the river by the employment of unencumbered channels.

Under the first head come the use of ice-boats and the employment of preventive floating booms to keep the ice from returning up the river with the tide. I consider that machinery of this latter kind is too cumbrous and costly to be regarded as of practical value. The care of it when out of use during most of the year, and its maneuver and protection when in place, appear too difficult for me to advise its employment.

Ice-boats are generally recognized, and practical machines proved to be serviceable in a number of places. The first one employed here was put into operation in 1837. It was a wooden boat, and did good service for some thirty years. In 1867 this machine was replaced by a new one of iron, and in 1870 a second iron boat was added, so that two have been in service during the past winter. In order to have reliable and precise information respecting the services rendered by these machines, and of the daily condition of the river, I sought to obtain copies of their log-books for the winter, but learned that they would not be of much service for my purpose. The information collected on these subjects has therefore been derived from the daily items of the newspapers, from occasional observations made by my assistants when their duties called them to the river-shores, from information derived from observers or correspondents at Marcus Hook, New Castle, and Reedy Island, (where there are ice harbors,) from Fort Delaware and Fort Mifflin, where there are engineer establishments, and from merchantile gentlemen here interested in the subject. The particulars of this information are given in Appendix D of this report. It is apparent that the ice-boats are of the greatest service; that their value is fully understood, and that with increasing foresight and care, and the provision of a third or spare boat, the ice difficulties of the river can be practically overcome. The cost of this apparatus is a material question, tending to determine the policy of their use. I append a copy of a communication on the subject from the late

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president of the board of trustees of the city ice-boats, Appendix D. It appears from this paper that the first cost of a good ice-boat is about $160,000. If these vessels (hulls and boilers) last an average of ten years, and the engines thirty-five years, and the cost of the engines be taken for each boat at $33,000, then the hull and boiler will cost $127,000.

One-tenth cost of hull and boiler	$12,700
One thirty-fifth cost of engine	1,000
Annual repairs	3,800
Annual cost of running	10,300
Average yearly cost of one boat	27,800
Average yearly cost of three boats	$83,400

This is equivalent to the permanent sinking of about $1,000,000.

I pass now to the third class of remedies, and will discuss the second afterward. It is evident that there are several methods of avoiding the winter difficulties of the Horseshoe navigation. There are some advocates for making Delaware City or New Castle, &c., winter ports for Philadelphia. Railroads are built, or in progress, connecting these points with Philadelphia and the interior of the country. At New Castle a costly shipping-pier was constructed, eight or ten years ago, for loading vessels with coal. These methods do not appear to me, however, to meet the case.

It is well known, also, that the Schuylkill River now affords access for vessels engaged in several extensive branches of commerce to important commercial depots of the city. Vessels of the largest tonnage and draught can now load and discharge cargoes on this river.

A daily trip of an ice-boat up and down the river during the past winter has sufficed to keep its navigation open, so that ships have been free to enter and depart at all seasons. It discharges into the Delaware, below the Horseshoe, and thus the particular difficulties of that navigation are avoided.

It is further to be remarked that the United States having entered upon the occupation of League Island, are preparing the "back channel" of the Delaware behind that island for the reception of naval ships of about 18 feet draught. Thus it is seen that the new Philadelphia navy-yard will afford free access for men-of-war to its docks by the Schuylkill and back channel, without encountering the embarrassments of the Horseshoe navigation.

It follows from these instances that an open artificial channel or ship-canal may be made which will extend the back channel from the Schuylkill through to the Delaware, into which it can debouche above Greenwich Point, and so afford an unobstructed route for the largest vessels to the wharves of the city on this river. There is no special engineering difficulty in the execution of this project. The land is low, which will make the excavation a minimum. There is no reason to doubt that the material is easy to remove, and may be deposited on the shores close to the work, with advantage to the vicinity for all purposes of commerce, manufactures, or city use. A cut of similar cross-section to the back-channel at its lower end should be practically permanent, requiring only moderate dredging at intervals to remove the deposits of river sediment. The formation of such a cut requires the appropriation of the ground through which it passes. This is a question for the owners. It would seem that its use for this purpose would very greatly enhance its value, to their advantage. It would become the site of wharves, docks, warehouses, and shipping-depots. The petroleum shipping-

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wharves of the Pennsylvania Railroad, and of other coal-oil shippers, and the Westmoreland Coal Company's wharves, are now established near where the outlet of this channel would be, and an examination of the map shows how rapidly the commerce of the city is seeking outlets in this locality. A second line for a canal is also traced on the map having its outlet higher up, just below the navy-yard. The location of such an aid to commerce as this is a question not so much of engineering as of business interest and advantage.

An open cut 150 feet wide at bottom, affording 20 feet depth at low tide, with side slopes of one on three from the back channel at Broad street bridge to the old powder-wharf above Gloucester Point, will cost about $1,300,000. A similar cut, entering the Delaware just below the navy-yard, will cost about $1,700,000.

I now return to the second class of remedies for the winter difficulties of the Horseshoe navigation, viz, technical works for the improvement of the existing channel-way. The causes of difficulty here are three: the *bend*, or rapid curving of the channel, the wide expanse of the river-surface, (allowing large quantities of ice to accumulate,) and the severe construction of the river in width at the upper exit from the Horseshoe region.

It is proposed to trace an artificial water-way through the Horseshoe which shall be limited, on its sides, by curves of as uniform curvature as possible, to arrange the surface of this water-way so that its width shall increase with careful uniformity from its up-river commencement to its down-river termination, to exclude the excess of ice from this artificial channel, and to widen the river at the Gloucester-Greenwich gorge, so that its shore-lines will conform to the adjusted curves of the Horseshoe passage.

I have traced upon the plan of the Horseshoe two lines which fulfill these conditions. They are curved as regularly as practicable from the navy-yard reach of the river to that of League Island. The width between them increases regularly from that of the upper water-way to that of the lower. The northern line has its position between 2 feet and 6 feet depth at low water. The southern line is in from 6 to 10 feet.

It has been commonly proposed to draw a curve from Gloucester Point to Eagle Point, and to construct on this curve a solid barrier of earth, timber, stone, &c., which should cut off Ladd's Cove and limit the flow of the river. But it is evident that such a structure would have to be placed, in its most important part, (the middle,) in deep water; that it would be liable to be undercut by the currents; that it would tend to create disease; would require a special outlet to be provided for Timber Creek, and would interfere needlessly with the fishing and other riparian rights of the owners of the shore. Especially, it would leave the channel with no barrier against the ice which accumulates on the flats of the Horseshoe and back channel on the north shore. This accumulation I regard as causing the largest amount of obstruction to the navigation. The ice accumulates on the north shore, is set across by northwardly winds, and packs on the south side—that is, in the channel.

Along each of the two curve lines which have been defined may be placed a series of ice-piers, at suitable distances apart, and so shaped as to check the passage of the ice from the shoals outside of them to the water-way between them. Being placed in shallow water, these piers will be of moderate size and of comparatively moderate cost. If built of crib-work up to low water, and of shaped-stone superstructure, they will cause but little disturbance of the currents, while they will

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restrain the excess of ice from drifting into the channel and producing an ice gorge. They must be shaped with wedging faces toward the ice, the better to prevent its drift when the wind blows across.

A better material for these piers will be iron, to be used in the shape of piles, and secured in the bottom with Mitchell's screw disks. These piles, well braced together, will constitute an ice-pier as effective as the crib and stone structures, and will practically cause no obstruction to the currents. All the uses and conditions of the river will be unchanged, except that the obstructions caused by the ice will be reduced from extraordinary to ordinary limits.

In distributing the ice-piers, it is proposed to place them, first, at intervals of about 400 feet on each line. The effect of these will show where they should be closer together, and to what extent the intervals should be reduced by introducing intermediate piers. It is probable that they will need to be much closer at the upper end of the line, on the Greenwich side.

On the New Jersey side, it is considered that some may be omitted just below Gloucester Point. The Pennsylvania line will terminate above League Island; the New Jersey line, above Eagle Point.

While a solid barrier of crib-work, with earth or stone, will satisfy the requirements of the question, and detached ice-piers formed of the same materials (or, still better, of iron piles) will probably suffice, and these latter with less likelihood of injury to the river, to health, and to shore interests, I have formed the opinion that a simple open barrier of iron, to be continuous along the lines to be guarded, will be more effective, without hazard of injury to the channel, to the health of the shores, and the vested rights of owners, and will be of less cost than either of the other structures proposed. This barrier is composed of pairs of iron screw piles, placed about 15 feet apart, along the lines marked on the chart, the piles of each pair sloping apart, at the bottom, crosswise of the channel, and touching at the top, where they are to be clamped together. The pairs are connected by longitudinal, horizontal iron ties along the top of the line and by pairs of oblique diagonal braces, tha stiffen the whole structure. This system affords a stiff frame, perfectly open to the water, and rising about 4 feet above high-water mark. Between tides, on the channel side, horizontal timbers 6 by 12 inches are secured to the iron frame by proper fastenings. The currents will flow freely through this structure, but the ice cannot pass it, and the powerful hold of the screw-disks in the bottom will afford great stability against the pressure of ice or vessels. The frame-work may be further stiffened by the use of horizontal struts and cross-diagonal braces. (See estimate of cost, in Appendix E.)

The solution of this question will not be complete until the gorge of the river on the Gloucester-Greenwich line is opened. It is evident that the surface is materially constricted on that line, and it is not to be expected that the ice will flow naturally up and down stream until the river is properly widened at this position.

The line traced on the New Jersey side cuts off Gloucester Point, and reduces somewhat the projection into the river of the upper wharves.

The line on the Pennsylvania side coincides with the present limit of Greenwich Point wharf, and reduces the projection of the next three wharves above, materially.

It will be noticed that the port-warden's line has latterly (November 16, 1867) been varied in this locality, and that more projecting wharves are contemplated at Greenwich Point, as well as others in the vicinity.

I am of opinion that the construction of such new wharves will be of

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serious detriment to the navigation during the ice season; that the port-warden's line should be moved back to its former position, and that the removal of Gloucester Point and the shortening of the wharves above are very important to the improvement of the navigation of the Horseshoe region.

Whatever remedial measures are adopted, the continued moderate use of ice-boats is indispensable. The abundant use of these boats, without the employment of other measures, can be made effective to keep the navigation practically unclosed; but no other devices will suffice without their use, for they would be useful even if the river had everywhere a straight and uniform channel.

Estimates of the probable cost of the several works proposed are appended to this report. No estimate is made of land damages, or of the value of property to be affected by the improvements.

I have received the same courteous and liberal assistance from the United States Coast Survey, in the examination of this subject, that has always been afforded by that establishment to like investigations requiring aid from it, and I desire to make a special acknowledgment. therefore, in this report.

* * * * * * *

Respectfully submitted.

J. D. KURTZ,
Lieutenant-Colonel of Engineers.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, U. S. Army, Washington, D. C.

R 13.

Estimate of cost of continuous open iron ice barriers for the improvement of the winter navigation of the Horseshoe region of the Delaware River.

Materials.	Designation.	Price.	Cost.
ROLLED IRON.			
	Pounds.		
2,600 piles, 29 feet by 4.5 inches, 29x2,600x53.01	3,996,954	$0 08	$319 [illegible]
5,200 longitudinal braces, (diagonal,) 22 feet by 2½ inches, 22x5,200x13.25.	1,463,800	10	146 [illegible]
2,600 cross-braces, 11 feet by 2 inches, 11x2,600x10.47	299,442	10	29 [illegible]
1,300 horizontal longitudinal braces, 16 feet by 2½ inches, 16x1,300x16.36.	340,288	10	34 [illegible]
HAMMERED IRON.			
1,300 top bands, 90 pounds each	117,000	15	17 [illegible]
7,800 turn-buckles, 40 pounds each	312,000	25	78 [illegible]
10,400 bolts, 1.5 pounds each	15,600	15	2 [illegible]
15,600 bolts, 13 pounds each	202,800	15	30 [illegible]
1,300 turn-buckles, 50 pounds each	65,000	25	16 [illegible]
5,200 collars, 75 pounds each	390,000	15	58 [illegible]
36,400 staple bolts, 6.5 pounds each	236,600	10	23 [illegible]
CAST-IRON.			
2,600 screws, 250 pounds each	650,000	06	39 [illegible]
1,300 struts, 200 pounds each	260,000	06	15 [illegible]
TIMBER.			
819,000 feet board measure timber	.....	40 00	32 [illegible]
WORKMANSHIP.			
	Days.		
Receiving and putting down 2,600 piles	11,000	2 00	22 [illegible]
Adjusting collars, braces, fender timbers	2,500	2 00	5 [illegible]
Blacksmith labor	626	3 00	1 [illegible]
Services of diver	600	9 00	5 [illegible]
Labor in care and repair of machinery	2,000	2 00	4 [illegible]

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Estimate of cost of continuous open iron ice barriers, &c.—Continued.

Materials.	Designation.	Price.	Cost.
MACHINERY AND APPARATUS.			
Scow with pile-driver			$1,800 00
Portable-engine			1,800 00
Three boats			500 00
Steam launch			2,000 00
Cordage, tools, &c			3,000 00
	Pounds.		
Eight anchors, 250 pounds each	2,000	$0 12	240 00
Four anchors, 100 pounds each	400	12	48 00
Machinery for putting down piles			6,000 00
Scow for carrying piles			1,000 00
Diving apparatus			1,500 00
CONTINGENT AND UNFORESEEN EXPENSES.			
	Months.		
Engineer	30	150 00	4,500 00
Overseer	30	120 00	3,600 00
Inspector	30	150 00	4,500 00
Clerk	30	120 00	3,600 00
Draughtsman	30	120 00	3,600 00
Stationery, transportation, freight, postage, &c			4,000 00
Unforeseen expenses, 15 per cent			138,623 30
Total			1,062,778 62

RECAPITULATION.

Materials	$844,189 32
Workmanship	38,278 00
Machinery and apparatus	17,888 00
Contingent and unforeseen expenses	162,423 30
Total	1,062,778 62

J. D. KURTZ,
Lieutenant-Colonel of Engineers.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pennsylvania, June 17, 1872.

R 14.

BROADKILN RIVER, DELAWARE, COHANSEY CREEK, NEW JERSEY, THE BAY OR SOUND FROM DELAWARE LINE THROUGH WORCESTER COUNTY TO CHINCOTEAGUE INLET, VIRGINIA, WITH A VIEW TO AN INLET AT OR NEAR A PLACE CALLED THE HOMMACKS, DELAWARE RIVER, BETWEEN TRENTON AND EASTON.

The survey of the Broadkiln is complete.

The survey of Cohansey will be taken up shortly, and the results will be reported in season for the next meeting of Congress.

The survey of the "Hommacks" will be organized as soon as possible, and the maps and report are expected to be completed and rendered in season for the action of Congress.

The survey of the Delaware River will be commenced as soon as practicable, and the map and report transmitted in season for the consideration of Congress.

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UNITED STATES ENGINEER OFFICE.
Philadelphia, Pennsylvania, September 11, 1872.

GENERAL: I have the honor to transmit herewith a "survey of the Broadkiln River, Delaware," made in conformity with your instructions of March 25, 1872. The survey was executed by Captain M. R. Brown, Corps of Engineers, and by Mr. James A Chase, assistant engineer, under his immediate direction.

The papers consist of a report, including an estimate of the cost of the improvement desired, and five maps, marked sheets A, B. C, D, and E.

Sheet A is reconnaissance of Broadkiln River.
Sheet B is Broadkiln River.
Sheet C is Broadkiln River.
Sheet D is Broadkiln River.
Sheet E is Broadkiln River.

The papers show that the present entrance into the Broadkiln from Delaware Bay affords very little water at low tide, and that it is constantly disturbed by shifting sand, while the entrance itself is advancing rapidly up the beach, under the transporting action of the tides. Fifty years ago there was an entrance to Lewes Creek, at a point called "Old Inlet," 6,000 or 7,000 feet above its present junction with the Broadkiln. The land between Lewes Creek and the bay is very narrow at this point, and the bay-shore is free from drifting sand. This inlet was opened by a storm twenty-five years ago, and was in use until it was closed by artificial causes.

Captain Brown recommends that this inlet be re-opened by a cut across the beach, and the waters of the Broadkiln and Lewes Creek be discharged through it into the bay.

The cost of making this opening is estimated by him at	$14,7[illegible]
It is also proposed to dredge and clear the course of the Broadkiln, so as to afford a uniform depth of 6 feet at low water. The cost of this and of a dam to turn the waters from Lewes Sound toward the new inlet, is estimated at	65,65[illegible]
Making the total cost of the desired improvement	$80,45[illegible]

Statement of funds.

Allotment from appropriation for examinations and surveys on the northern and northwestern lakes, rivers, &c	$[illegible]
Expended to June 30, 1872	[illegible]

Respectfully submitted.

J. D. KURTZ.
Lieutenant-Colonel of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. Army, Washington, D. C.

EXAMINATION AND SURVEY OF BROADKILN RIVER, DELAWARE.

On the 16th of March, 1872, a communication, of which the following is a copy, was received by me at the engineer office in Lewes, Delaware:

"OFFICE OF THE CHIEF OF ENGINEERS,
"*Washington, D. C., March* 14, 1872.

"COLONEL: The inclosed copy of a resolution of the House of Representatives of the 11th instant, requesting an examination and survey of the Broadkiln River, Delaware, &c., is transmitted to you for report.

"Please ascertain the probable extent of the required survey, and an estimate of the cost of making it.

"By command of Brigadier-General Humphreys.

"Very respectfully, your obedient servant,

"JNO. G. PARKE,
"*Major of Engineers.*

"Lieutenant-Colonel J. D. KURTZ,
"*Corps of Engineers, 1330 Chestnut street, Philadelphia, Pennsylvania.*"

"FORTY-SECOND CONGRESS, SECOND SESSION.

"CONGRESS OF THE UNITED STATES,
"*In the House of Representatives, March* 11, 1872.

"On motion of Mr. Biggs—

"*Resolved*, That the Secretary of War be requested to cause to be made an exami

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nation and survey of the Broadkiln River, in the State of Delaware, with a view to ascertain the practicability of dredging and improving the same, so as to afford greater protection and facilities to commerce; and that he report upon the feasibility of making such improvement, and the probable cost thereof, to the House of Representatives.

"EDW'D McPHERSON, *Clerk.*

"Indorsed:

"UNITED STATES ENGINEER OFFICE,
"*Philadelphia, March* 15, 1872.

"Respectfully referred to First Lieutenant M. R. Brown, Corps of Engineers, for prompt report of the probable extent and cost of the required survey.

"J. D. KURTZ,
"*Lieutenant-Colonel of Engineers.*"

The reply to these instructions was as follows:

"LEWES, DELAWARE, *March* 20, 1872.

"SIR: Your instructions of the 15th instant, calling upon me to obtain information to serve as the basis of an estimate for the probable cost of the survey of the Broadkiln River, required by the United States House of Representatives on the 11th instant, also directing me to make and forward the necessary estimate, has been received.

"On the 18th instant, I had an interview with his excellency, James Ponder, governor of the State of Delaware, on a bank of the Broadkiln River, having myself proceeded to Milton, on the above-designated stream, which is, by water, fourteen miles from its mouth.

"Here I took a boat and proceeded down the river to the sound, meeting the governor *en route*. He is at the head of the movement for the improvement of the river, being largely interested pecuniarily in the industries of Milton, of which he is also a resident. He states that last year the entries of vessels, mostly schooners, amounted to 50,000 tons, and $30,000 worth of oak-bark alone were shipped by himself. The shipments of wood are also considerable. Three schooners are now at the stocks at Milton in various stages of construction, one of them being of 600 tons burden. This was the utmost extent of definite information I could obtain relative to the commercial importance of the river. The town of Milton, the only one on the river, contains about one thousand inhabitants.

"The river is crooked, having a muddy bottom and banks, and throughout the seven miles just below Milton the latter are covered by a thick and almost impenetrable growth, called alder-bushes. It is very soft and swampy also.

"Since most of the obstructions are comprised in the lower seven miles of the river, it is not considered necessary to make a careful survey of the entire meanderings to Milton, but only to survey carefully the lower half or more, including the sound into which the river empties, and also Cape Lewes, which separates this sound from the Delaware Bay, and to extend the work also to such portions of the river higher up as include reaches where canals and other improvements are desired. For this purpose it is believed that $600 will be ample.

"I am, very respectfully, your obedient servant,

"M. R. BROWN,
"*First Lieutenant, Corps of Engineers.*

"Lieutenant-Colonel J. D. KURTZ,
"*Corps of Engineers, U. S. A.*, 1330 *Chestnut street, Philadelphia, Pa.*"

March 29, the following reached me:

"OFFICE OF THE CHIEF OF ENGINEERS,
"*Washington, D. C., March* 25, 1872.

"COLONEL: Your letter of the 21st instant is received. You will cause a survey to be made of the Broadkiln River, Delaware, as contemplated by the resolution of the House of Representatives of the 11th March, a copy of which was sent you March 14. The expense of the survey will be paid from the appropriation for examinations and surveys on the northern and northwestern lakes and rivers, and the Atlantic and Pacific coasts, &c. And the amount of your estimate, $600, will be set aside for the purpose.

"By command of Brigadier-General Humphreys.

"Very respectfully, your obedient servant,

"JNO. G. PARKE.
"*Major of Engineers.*

"Lieutenant-Colonel J. D. KURTZ,
"*Corps of Engineers, 1330 Chestnut street, Philadelphia, Pennsylvania.*"

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First indorsement:

"UNITED STATES ENGINEER OFFICE,
"*Philadelphia, March 28, 1872.*

"Respectfully transmitted to First Lieutenant M. R. Brown, Corps of Engineers, who will make the survey as directed, and send it with report to this office as soon as completed.

"The report should state the ship-building, manufactures, commerce, and navigation of the river; what benefits are expected from the improvement; what is the nearest port of entry; the amount of revenue collected there the last year, &c.

"J. D. KURTZ,
"*Lieutenant-Colonel of Engineers.*"

To indicate the steps taken to carry out these instructions, the following extract from my monthly report for April, 1872, is inserted:

"In the following detailed instructions from me, Mr. James A. Chase took charge of the main party in the field on the 1st of April. On the 2d, I proceeded to Philadelphia, in pursuance of your orders. On the 4th of April the men engaged on the work refused to continue on it, in consequence of the high charge for board made by the farmers living on the banks of the river. They refused to receive the men for less than $1 per day each, some asking as high as $2 per day. As $1.60 was the amount earned per man, the party felt unable to afford five-eighths of this for board, and in my absence Mr. Chase did not think himself authorized to pay the men more. The 4th, 5th, and 6th of April, fine working-days, were thus lost. I returned to Lewes on the evening of Saturday, 6th, and at once arranged the trouble satisfactorily to the men.

"On the 27th of April most of the field-work, embracing much shore-line not strictly on the Broadkiln itself, was completed. Over a part of the surveyed tract it is impossible to run transit-lines, from the softness of the ground; therefore two miles of the river were surveyed by compass and by line, and real measurements made from boat to boat.

"Eleven miles of transit-lines were run along the reaches of the Broadkiln itself, and sixteen miles of transit-lines auxiliary to those first designated. About thirty-five miles of lines of soundings were established, and 15,081 soundings were made on these lines, besides many in Delaware Bay, in the course of the survey of the harbor for a board of engineer officers. About 500 measurements were taken to ascertain the widths of the river," &c.

During the month of May the field-work consisted in the staking out and leveling of such lines for canals as have been suggested by those citizens who are interested in the improvement of the navigation of the river, also in the "running" of certain transit-lines for use in checking work previously performed. In the aggregate these lines amount to about twenty-three miles.

The tortuous nature of the stream, and the many points which present formidable difficulties to navigation, caused the survey to present a very detailed character, and necessarily made the office-work extend over a considerable period. It was found impracticable to finish the maps and charts in season to allow of their presentation to Congress previous to its adjournment, then impending, and in order to economize the cost of the survey, work was prosecuted, after the adjournment of Congress, at such times as not to interfere with other matters to which the attention of assistants was principally directed.

Drawings exhibiting the information obtained in the survey, and estimates of cost of all improvements desired by those interested in the commerce of the Broadkiln River, were completed on the 17th of July, 1872. They are forwarded with this report. The drawings are contained in four sheets, and include on Sheet B a chart of the Broadkiln River, from the dam at Milton to its mouth, including the sound into which it empties, a portion of Lewes Cape, &c. Sheet C is a continuation of Sheet B, to the eastward. Sheet D is a detailed chart showing portions of the Broadkiln River at Milton and Carey's Landing, exhibiting principally, in a minute manner, the depths of water at points where improvements are suggested. Sheet E refers to Hevelloe's Landing, Cedar Landing, and Green Island, Canal, Hudson's Landing, Drawbridge, Wiltbank's Landing, and the drawings are of the same character as those on Sheet D.

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Estimates of the cost of the various improvements.

No.	Nature of improvement.	Location.	Marks on the map.	Feet in—			Minimum channel depth at low water.	Quantity—cubic yards.	Cents per yard.	Cost.
				Length.	Width.	Mean depth.				
1	Dredging	Milton	546—559	1,300	70	5	0.4	16,852	35	$5,898 20
1	Cut	Rattlesnake Hill	0—7	800	40	8	0.0	9,482	40	3,792 80
1	Cleaning and grubbing	....do	0	800	100			485 sq. yards	1 00	485 00
2	Dredging	Carey's Landing	494—496	400	100	3	3.4	4,444	35	1,555 40
3	....do	Hevelloe's Landing	414—416	250	50	3	4.7	1,111	35	388 85
4	....do	Cedar Landing	359—365	600	60	3	3.4	4,000	35	1,400 00
5	....do	Canal	351—359	800	60	2	4.4	3,555	35	1,244 25
6	....do	Hudson's Landing	337—344	700	60	2	4.0	3,111	35	1,088 85
7	....do	Drawbridge	299—301	200	60	3	4.4	1,333	35	466 55
2	Cut	....do	0—19+65	2,0.0	40	9.2	+3.2	27,360	40	10,944 00
3	....do	Wiltbank's Landing	198—219	1.000	40	9.2	+0.2	13,680	40	5,472 00
8	Dredging	....do	198—208	1,000	80	2	4.0	5,926	35	2,074 10
4	Cut	No Man's Ford	0—20+81	2,100	40	9.2	+3.2	28,622	40	11,448 80
9	Dredging	Green Island	{27+60 / 37+60}	1,000	80	4	3.2	11,852	35	4,148 20
5	Two cuts	Old Lewes	160+87							
	....do	Creek Inlet	180—21—87	2,000	40	11	+5.0	32,593	40	13,037 20
	Dam	Below mouth Broadkiln	9—75	300	10	9		1,000	40	400 00
	....do	....do	9—75	300				60 piles	$5.00	300 00
	....do	....do	9—75	300				25,200 ft., b. m.	$60.00	1,512 00
	Six cuts	At mouth Broadkiln	{1—82+72 / 99+49—E}	1,950	40	12.8	+6.8	36,977	40	14,790 80
										80,447 00

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The estimate for a cut at Wiltbank's Landing was made in order to ascertain the relative cost of each of two methods of improvement. Dredging is recommended on account of its economy. The idea most popular with the residents on the banks of the Broadkiln, with reference to securing a more direct outlet from the river to the bay, is to cut across Lewes Cape in a prolongation of the lowest reach of the river. The method suggested here is to obstruct the old channel just below the mouth of the Broadkiln, by driving piles about 10 feet apart in two rows, themselves 10 feet apart, and to drive sheet-piling against wall-pieces secured to these piles, filling in between these wooden walls with earth, thus making a dam. In actual construction, driving the sheet-piling should be prosecuted from each bank outward simultaneously. Previous to this work, however, a channel should be cut across the peninsula that separates Lewes and Broadkiln Rivers from the Delaware Bay, and a very favorable locality for this cut seemingly is about 6,000 feet above the junction of the Broadkiln with the sound, at a place marked "Old Inlet" on the map, indicated by the close approach of the inner waters with the Delaware Bay, thus connecting artificially Lewes Creek and Delaware Bay.

In case this cut is made, it will be necessary to lead the water of Lewes Creek to the Bay by a cut along a line which corresponds to a channel formerly constituting the outlet of Lewes Creek, but which disappeared after the digging of the canal indicated on the chart.

Most of the ground which would have to be removed to make these two cuts is ordinary meadow material, and the apparent tendency of the waters to make channels for themselves here, indicates the probable permanency of cuts artificially made. This locality seems to be exceptionally free from the deposits made by the flood-tides at most other points along the coast in the vicinity. Immediately opposite the mouth of the Broadkiln, the cut would be through sand. Were the cut across the peninsula made at any one of several other localities, the expense would be about the same.

The dam across the channel, below the mouth of the Broadkiln, appears indispensable regardless of the lines chosen for the cuts. The cuts designated as 5 and 6, each number embracing two channels on the table, are alternatives. The table indicates all the localities where improvements are desired by the commercial interest endeavoring to secure an appropriation.

The improvement most anxiously wished for, is the opening of a better route from the Broadkiln to the Delaware Bay; vessels are frequently unable to reach the bay, after having passed through the river's mouth, on account of the direction of the wind, and sometimes, in consequence, are detained several days, remaining within about a mile and a half of the entrance to the bay. In this respect the difficulties of navigation increase year by year, since the point of Lewes Cape is advancing steadily up the bay, thus giving a greater length to the sound, and indicating, apparently, the futility of attempting to keep open by dredging a deep channel through the inlet now connecting the bay and sound. This knowledge warns us to choose such a locality for artificial channels, that the work accomplished shall not be undone by constant accretions of sand filling up the cuts to be made, and, in this view, the wisdom of cutting the new canals at the places suggested, which are comparatively if not entirely beyond the influence of the permanent deposits by the flood-tide, receives confirmation.

No deposits of sand are to be seen near here. The locality is known as the "Old Inlet." Some twenty-five years ago, during a violent northeast storm, and through its agency, this inlet was made. Its history, during the fifteen years it was in use, indicates that it might have remained open until to-day, had not the inhabitants of Lewes, annoyed by bars which formed the inlet, possibly in consequence of its direction, nearly parallel with the coast, caused a canal to be cut, joining the waters of Lewes Creek and what was then known as the "Old Back Channel;" thus dividing the ebb waters into two components.

Experience may or may not show it to be necessary to obstruct this canal after the formation of the new channels. According to the most reliable information at hand, Lewes Cape has extended itself about a mile and three-quarters in less than half a century. Its extreme point, about the time work was begun on the breakwater, was opposite the mouth of the Broadkiln River, which has remained nearly or quite in its former position. There is no evidence that this is due solely, or even in any degree, to the presence of the stone piles, since the extension had been in progress at the date above referred to.

The directions of the new channels suggested for the Broadkiln's mouth would be very favorable for the entrance of vessels. The present inlet is extremely unfavorable. The bay of the Old Inlet is quite free from shoals, while they are very many and troublesome just beyond the present entrance to the sound from Delaware Bay.

It is thought that the tables and charts, taken together, render any other mention of particular works called for unnecessary. The improvements designated will result in a depth of six feet at low water throughout the river.

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The expense of the survey has been as follows:

Field-work, labor	$481 94
Field-work, material	10 30
Office-work, labor	100 00
	592 24

The nearest port of entry is Wilmington. At this port for the last fiscal year the collections were as follows, viz:

Duties on importations	$39,711 99
Hospital tax	2,204 18
Steamboat fees	542 50
Tonnage tax	62 10
Total	42,530 77

The title of the collection district is "Delaware." At present the commerce entering and departing from the mouth of the Broadkiln River embraces about 55,000 tons annually. The average value of shipments is about $10 per ton. A commerce exceeding half a million of dollars per year is, therefore, the nucleus of a trade which would unquestionably receive a great impetus from the improvements suggested. It is estimated that within a year after the completion of the improvements desired, a commerce of $2,000,000 per year would be permanently established. Seven-eighths of the present tonnage of the river enters and departs from Milton. The remainder is distributed among five other points, called landings, indicated on the principal chart forwarded. The out-shipments consist mainly of quercitron and Spanish oak-bark, lumber, partly manufactured and unmanufactured, hickory stuff for ax-helves, and timber for ship-building. The return cargoes embrace general merchandise, fertilizers, lime, and other building materials, &c. The manufactures on the river are the products of two saw-mills and one bark-mill. At present about 2,000 tons of vessels are built on the banks of the river yearly, the average tonnage of the vessels launched being 400 tons. It is anticipated that, with the desired improvements of the river, the ship-building will increase five-fold. This expectation is founded on the fact that ships are built very cheaply on the river, and that the great drawback heretofore encountered has been the shallowness of the water preventing the exit of deep-draught vessels. It is thought also that vessels of greater draught from southern ports, which are now prohibited from the commerce of the river, will enter laden, after the suggested improvements are made. All ships of considerable tonnage now built on the river are obliged to leave without cargoes; but, under better conditions, it is said they would leave laden.

It is claimed that the amount of shipments of all kinds will be increased many fold when deeper-draught vessels can navigate the river, and thus all industries now pursued on its banks would be stimulated.

Tug-boats cannot profitably be used on this river at present, as they can only run during high water; but, were it not for the shoals, it is said propeller tugs would be used freely, tending to keep the river free from deposits, and aiding greatly in the ease of navigation.

Very respectfully, your obedient servant,

M. R. BROWN,
Captain Corps of Engineers, U. S. A.

APPENDIX S.

ANNUAL REPORT OF LIEUTENANT-COLONEL JOHN NEWTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Army Building, New York, September 5, 1872.

GENERAL: I have the honor to submit herewith my annual report upon the following works under my charge for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

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S 1.

IMPROVEMENT OF THE HUDSON RIVER, BETWEEN TROY AND NEW BALTIMORE, PORT SCHUYLER DIKE.

This dike, built by the United States in 183–, and repaired in 1866, as far as was then needed, is a subject for further repairs.

The waters escape through breaches in the dike, and deprive the main channel of a certain amount of scouring force.

The dike, as originally constructed, was composed of a cove of sand and gravel, paved on the exterior with stone. The breaks in the pavement, caused by the shocks of ice and other floating bodies, lead to a rapid wearing away of the interior of the dike. The remedy thus far applied has been to fill the excavations with rubble-stone. The repairs of this dike are urgent, and as the effect of the currents is to increase still further the extent of the breach, should be undertaken with the first available funds. About 3,000 cubic yards of stone will be required to make these repairs.

BASE ISLAND CRIB-DIKE.

After the subsidence of the spring freshets of 1871, the necessity of repairs to this dike was revealed. Some of the timber-work was displaced, and a considerable part of the original filling of sand and gravel washed away.

The repairs of the timber-work cost $497.69. A contract, dated October 18, 1871, was also entered into with Mr. Emory R. Seward, of Albany, for the delivery of 5,000 cubic yards of stone-filling for this and the Upper Patroon's Island dike, the delivery to be completed by May 1, 1872. The lateness of the commencement of delivery, the early close of navigation, and the frequent floods in the spring, rendered the completion of the contract within the specified time impracticable, and the time has been since extended to December 1, 1872. No payments are due under this contract until its completion. Two hundred and fifty-three cubic yards were received, and deposited in this dike under the contract.

A recent examination of this dike has developed the existence of two bad breaks; one caused by a vessel dragging its anchor and going over or through the dike at a high stage of water; the other by the settlement of the channel-face of the dike, causing a rupture of the ties.

The amount of repairs, exclusive of stone-filling, is estimated by Lieutenant J. H. Willard, Corps of Engineers, assistant engineer, at $1,031.28, and these will be undertaken during the present season.

UPPER PATROON'S ISLAND CRIB-DIKE.

After the spring freshets of 1871, an examination showed the necessity of certain repairs. The cribs in several places inclined so much toward the channel that it was necessary to drive piles, 71 in number, to prevent a further careening. The channel-face of the cribs, to compensate for settlements, was leveled up with hemlock timber for a distance of 1,600 feet.

Twelve hundred and twenty cubic yards of stone were received and deposited in this dike under E. R. Seward's contract.

The expenditures for repairs, excluding stone, amounted to $990.61.

The present condition of this dike is good, and it requires only the completion of the stone-filling.

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DREDGING FISH-HOUSE SHOALS.

This shoal, situated just below the end of the Base Island dike, was dredged during the last season, commencing in the latter part of July, 1871, and finishing in August. The amount of material, coarse sand, and gravel taken from the shoal was 8,940 cubic yards, which was, in greater part, deposited behind the Bath dike. The cut made was 1,400 feet long, 60 feet wide, and to a depth of 8 feet at mean low water. Owing to the dikes this depth has been virtually maintained, it being, at the date of this report, 7½ feet, against 6.2 feet at the former period. The effect of the dikes has been likewise marked, in sensibly widening the channel between the 6-foot curves.

In my last annual report I recommended the extension of the Base Island dike down stream for a distance of about 2,000 feet, and my opinion has been confirmed by the evidence of the good effect of the present lengths of these dikes.

It is more than probable that such extensions would maintain an 8-foot channel.

The cost of dredging at this shoal, including relifting and depositing behind the Bath dike, was 35¼ cents per cubic yard, measured in scows.

The estimated cost of the extension of the Base Island dike, down stream, for a distance of 2,000 feet, is $14,000.

BATH DIKE.

The head of this dike needs some protection against the ice. Some filling with stone is also required.

CUYLER'S BAR.

Dredging is being done here by the State commissioners. The United States have not performed any work at this locality; previous annual reports recommend another dike parallel to the existing dike, built by the State commissioners.

This construction would prove a remedy against the periodic filling of the channel over Cuyler's Bar.

OVERSLAUGH DIKE.

Along the lower reach of the channel, a cut, for temporary convenience of commerce, was made in September, 1871. The cut was 1,900 feet long, 25 feet wide, and to a depth of 12 feet at mean low water. The amount removed, which bore striking evidences of ashes and cinders deposited from steamboats, was 7,820 cubic yards, at a cost of 22.7 cents per yard, measured in the scows.

The State commissioners during this season are dredging at the upper and lower ends of the Overslaugh Channel.

Previous annual reports contain a recommendation to construct a dike parallel to the present dike, which it is believed will obviate the necessity that occurs nearly every year of dredging in the channel.

OVERSLAUGH ROCK.

The removal of this rock, under contract of Emory R. Seward, has not progressed since the date of the last annual report, though the time of the contract was extended for this purpose to July 1, 1872.

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The least depth over the rock is 11.7 feet at mean low water, which answers all demands of navigation. The depth to be attained, as specified in the contract, was to be 12 feet at mean low water.

CEDAR HILL DIKE.

The gap of 1,000 feet, left at the construction of this dike, will be closed under the present appropriation. A section of this dike, 350 feet in length, constructed in shoal water, has been caught by the ice, and raised somewhat from its bed. The repairs would probably cost $2,400.

MAIN CHANNEL AT COEYMAN'S.

A point of the "Middle Ground," projecting into the main channel, was dredged off during the last season. The amount removed was 7,825 cubic yards.

The cost was 18.65 cents per cubic yard, measured in the scows.

This operation would not have been necessary, had the dikes now constructed at Coeyman's been then in place.

CHANNEL LEADING INTO COEYMAN'S.

The prolongation of the Roah Hook dike, which would cut off the existing channel, made it necessary to dredge a narrow passage for the convenience of commerce. A cut 900 feet long, by 25 feet wide, was made, and 5,190 cubic yards removed, at a cost of 13.7 cents per cubic yard, measured in scows.

DIKES AT COEYMAN'S.

On September 2, 1871, a contract was entered into with Mr. James D. Leary, of Brooklyn, New York, for the construction of these dikes, known as the "Middle Ground dike," extension of "Roah Hook dike," and the "Barren Island dike."

The amount of funds available enabled me to contract only for the essential features of the plan, without giving to each dike its full length.

The contract was limited to December 10, 1871, but on account of the unusually early making of ice in the river, the time was extended to May 1, 1872, at which period the lengths contracted for were completed, viz:

Middle Ground dike, 2,056 feet, at $8.24 per foot.

Exterior of Roah Hook dike, 1,380 feet, at $8.19 per foot.

Barren Island dike, 816 $\frac{9}{12}$ feet, at $7.97 per foot.

It is intended to extend these dikes, as follows:

Middle Ground dike, 625 feet.

Roah Hook dike, 670 feet.

Barren Island dike, 740 feet.

The probable cost of extension will be $16,524.

The object of the system of dikes at Coeyman's, was to straighten and deepen the main channel, which has already been effected by the dikes to a considerable degree; and to furnish in addition a side channel leading up to Coeyman's, which from its position appeared to be cut off from water communication. The second part of this problem, difficult as it is, bids fair to be accomplished.

At all events, the plan adopted, which has been generously approved

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The project of operations under the appropriation of $40,000 for this improvement, (approved June 10, 1872,) which received the sanction of the Chief of Engineers, recognized the necessity of a resurvey of portions of the river before a judicious application of the funds could be made.

Accordingly, a surveying party, under the charge of Mr. F. Von Egloffstein, civil engineer, was dispatched in June, 1872, for a resurvey of the whole river between Troy and New Baltimore; in the first place, however, to finish the surveys of the points where it was proposed to extend existing or to erect new works. In accordance with his instructions, he has furnished maps of the channels at Coeyman's, at Cedar Hill dike opposite the gap in that dike, and at Fish-house Shoal, at the lower end of the Base Island dike; the changes which have taken place in these channels are a gratifying proof, as far as the surveys go, of the good effect of the dikes. The river divides itself into four sections, viz: from the nail-works in Troy to the railroad bridge at Albany; second, from Albany to the lower end of the Overslaugh dike; third, from Staats to a little below Castleton; and, fourth, from Roah Hook to New Baltimore.

I find it impossible, owing to the limited appropriation granted, to have completed more than the first section; and this is a misfortune, as important information, not only as to changes in the river, both for the past and the future, was expected to be derived from the survey, but likewise an accurate knowledge of the extent to which the improvements should be carried.

Expenditures during the year ending June 30, 1872.

Dredging Fish-house Shoals	$3,149 75
Repairs Base Island crib-dikes	497 67
Repairs Patroon's Island crib-dikes	990 61
Dredging Overslaugh Channel	1,776 50
Dredging Coeyman's main channel	1,459 15
Dredging Coeyman's west channel	710 50
Coeyman's Dike 1, 2, and 3	36,169 71
Resurveys, &c	2,041 45
Office expenses, &c	3,261 12
Liabilities under contract with E. R. Seward for removal of Overslaugh Rock, and for stone-filling of dikes	15,408 16
	65,464 64
Amount which will be expended during fiscal year ending June 30, 1873	$40,000 00

Amount asked to be appropriated for the fiscal year ending June 30, 1874:

Repairs of Fort Schuyler dike	$8,000 00
Extension of Base Island dike 2,000 feet	14,000 00
Dike parallel to Overslaugh dike, 7,000 feet	56,000 00
Dike parallel to Cuyler's dike	28,000 00
Removing old State dam on Overslaugh dike	7,000 00
Repairs of Cedar Hill dike	2,400 00
Half dike and dredging at Scamerhaun Island	27,600 00
	143,000 00

These operations, which should be no longer delayed, will bring the works of improvement nearly to a close.

The work is located in the fourteenth collection district.

The nearest port of entry is Albany, New York.

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The amount of revenue collected from imports for the fiscal year was $122,610.30. The value of same, $523,077.

The amount of commerce and navigation benefited, $500,000,000.

Abstract of bids for construction of pile and crib dikes between Troy and New Baltimore, on the Hudson River, opened August 18, 1871.

Bidders.	Dike No. 1.	Dike No. 2.	Dike No. 3.	Crib-dike
	Per linear ft.	*Per linear ft.*	*Per linear ft*	*Per linear ft*
Fuller & Marshall	$8 48	$8 48	$8 48	$9 ..
Edgar M. Payn	11 50	11 50	11 50	11 ..
Emory R. Seward	8 74	8 74	8 74	10 ..
Stephen Miles	8 74	8 74	8 74	12 ..
James D. Leary	8 24	7 97	8 19	11 ..
James Caldwell	9 50	9 50	9 50	.....
George Kellogg	9 40	9 20	9 20	.....

I certify that the above abstract is correct.

JOHN NEWTON,
Lieutenant Colonel Engineers, Brevet Major-General

Abstract of bids for furnishing 7,000 cubic yards, more or less, of rubble-stone in the dike above Bath, on the Hudson River. Opened September 18, 1871.

Bidders.	Price per cubic yard.
Emory R. Seward	$1 ..
William Fuller	1 ..
Marshall O. Caldwell	1 ..

I certify that the above abstract is correct.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General

S 2.

THE REMOVAL OF THE ROCKS OBSTRUCTING NAVIGATION IN THE EAST RIVER, INCLUDING HELL GATE.

The following table exhibits the lengths to which the several tunnels and galleries at the works at Hallett's Point have been driven:

	Feet.		
Tunnel No. 1	185	Tunnel No. 5*c*	..
Tunnel No. 1 *a*	82	Tunnel No. 6	..
Tunnel No. 2	172	Tunnel No. 7	..
Tunnel No. 3	196	Tunnel No. 8	2..
Tunnel No. 4	202	Tunnel No. 9	..
Tunnel No. 4 *a*	79	Tunnel No. 9*a*	..
Tunnel No. 5	190	Tunnel No. 10	1..
Tunnel No. 5 *a*	79	Tunnel No. 10*a*	..
Tunnel No. 5 *b*	23½	Tranverse galleries	..

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The number of feet of tunnels driven during the year was 1,653, and of tranverse galleries 653¾. The quantity of rock removed was 8,293 cubic yards.

Hand-drilling was partially superseded by the use of machine-drills, viz, the Burleigh and Diamond drills, the former having drilled 20,160.1 feet of holes, and the latter 7,071 feet.

Five compressors and two boilers for condensing air were set, and a suitable frame building erected over them. Air-pipes, conveying the air to the tunnels and galleries, were laid.

A new derrick, and hoisting-engine for its service, were put up.

Car-tracks in the tunnels and shaft, with a turn-table at their point of meeting, have been laid.

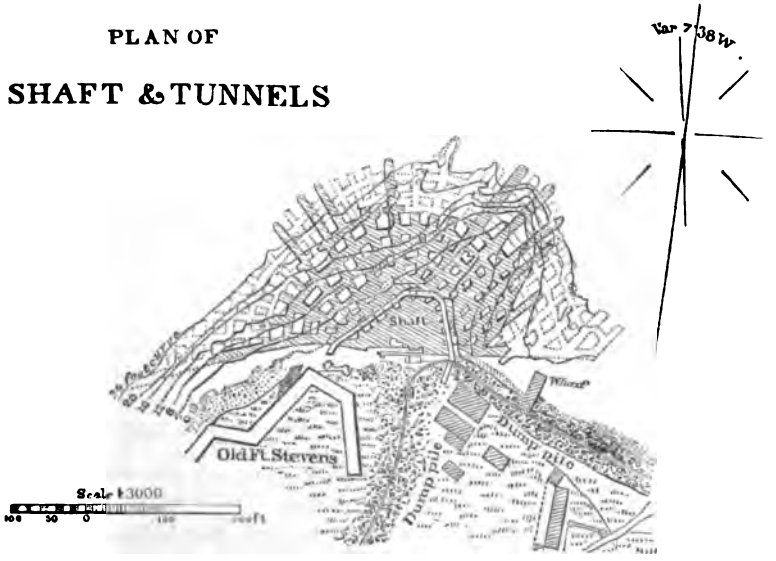
A small dummy-engine for hauling the excavated rock to the dump-pile was constructed.

Two diamond drills have been purchased and have been used, both as prospecting and as tunneling drills. As tunneling-drills, in comparison with the Burleigh drill, they appeared at first to be nearly equal in efficiency, but, as the work progressed, it is supposed on account of the rock becoming more difficult, they showed inferior results. For prospecting, however, and for drilling long holes, suitable to other purposes in mining, the diamond drill cannot be dispensed with.

It is not the intention to condemn the diamond drill as a tunneling-machine, for it is highly probable that, in rock not so hard as that at Hallett's Point, it would give excellent results. The sketch below will give a good idea of the progress of the work, and of what remains to be done in tunneling, in order to embrace the area of the rock to be removed.

PLAN OF

SHAFT & TUNNELS



I transmit likewise a plan and sections of the work, made in a scale of $\frac{1}{150}$.

The detailed survey of the rock has been made by Mr. William Preuss, surveyor and draughtsman, assisted by Mr. F. Sylvester, who have taken upon the reef more than 16,000 soundings, each separately located,

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by instruments from the shore. Great pains was taken to delineate exactly the surface of the rock.

It will be observed that seven of the tunnels are advanced to their full lengths, or nearly so; and the extent to which the rock has been perforated and seamed with excavations renders the assurance of a successful result as certain as human experience can make it.

The scale of progress of these tunnels, in comparison with that of tunnels driven on land, is, of course, small, for the necessity of precautions against the heavy mass of water above made it imperative to forbid deep blast-holes, large charges, and firing by volleys. With such restrictions, rapid progress became impossible.

It is to be regretted that the appropriation for the present year has been reduced to $225,000, just one-half of the estimate. I had hoped during this year to have been able to take the preliminary steps, as constructing the coffer-dam and sinking the shaft, toward the removal of the Gridiron, which lies between the eastern and middle channels, and constitutes at once the most dangerous reef in Hell Gate as well as the principal obstacle to its uses as a ship-channel. The removal of this reef should, in fact, have been undertaken simultaneously with that at Hallett's Point.

The doubt of success, however, in the beginning, which generally existed in the minds of the community, proved a sufficient excuse for the limiting of the operations to Hallett's Point. The case is now different; experience has proved that the process of tunneling can be successfully applied to the kind of rock of which these reefs are composed, and no further delay in enlarging the scale of operations should be permitted.

STEAM-DRILLING SCOW—DIAMOND REEF.

The number of holes drilled and blasted was 76, and of surface-blasts 44. The amount of nitro-glycerine consumed on this reef was 4,796½ pounds.

For the greater portion of the area of this reef the rock is met with in detached outcroppings, or in large bowlders, and the surface is generally covered with a tenacious deposit of earthy matter. It is, therefore, impossible to prosecute vigorously the work of blasting, because the bottom must be explored by divers, loose rock and hard pan removed, and soundings taken before a position for the dome can be selected. For these reasons operations have been intermittent here, and directed with the view of gradually obtaining the desired depth.

COENTIES REEF.

This reef has been thoroughly blasted, and is supposed to need only a few surface-blasts to further dislodge the portion seamed by blasts which will be left after the grapple is next removed. The number of holes drilled and blasted was 93, and surface-blasts 17. The amount of nitro-glycerine consumed was 5,479 pounds.

The grapple used to remove the blasted rock was the Morris & Cumings patent, and machines were hired of Morris & Cumings and of Mr. Shelbourne. The grapple is very effective in moderate currents and where the mass of loose stone to be removed is deep, but where the currents are rapid, and where the stone to be removed is thinly scattered over a large area, the use of the grapple is neither efficient nor economical. In the channel at Hell Gate the grapple could not be used by the Government, is in my judgment the only one which would likely effect the desired result, viz, the relief of Coeyman's.

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Notwithstanding, it would have been economical, as well as a saving of time, to have owned a grappling-machine which could have been applied at the time most advantageous for its use; but the funds for the purchase could never be spared from the appropriation. As it was, we were compelled to wait upon the convenience of those owning grapples, and to employ them when they had no other business on hand. Owing to this, we have moved the steam drilling scow from reef to reef, and have waited for the removal of stone until we have been able to secure the service of a grapple. The amount of stone removed from Diamond and Coenties reefs was 6,119 tons.

While waiting for a grapple upon Diamond and Coenties reefs, it was determined to remove the steam drilling scow to Hell Gate, and attack the "Frying Pan" and "Pot Rock." The scow was moored on "Frying Pan" first. Fifteen holes were blasted, and the machine was moored to "Pot Rock." After a few holes were drilled it was discovered that they were immediately filled by the loose stone on the reef. The dome has been used exclusively since to remove the loose stone with which the whole reef was covered; and it is the intention, for the future, to remove rock from the bottom in this way, to the virtual exclusion of the grapple. By this means a reef can be thoroughly cleaned off before leaving it.

The current in the East River was thought during Springs to be troublesome, but in Hell Gate it is simply terrible. The waters fairly run over the deck of the scow where the current impinges, and in the well-hole they rise above the dome to the level of the deck.

In the East River there were required 26,000 pounds of anchors; but in Hell-Gate 58,000 pounds are not too much. The operations of the dome are just as satisfactory in Hell Gate as they were in the East River; the swiftness of the current in no way interferes with its working or stability. During springs in Hell Gate the current is estimated between 9 and 10 knots.

Since the drilling-machine has been moored over Pot Rock, it has suffered from four collisions, in every case sending the colliding vessel to the bottom without damage to the scow. Fortunately, there has been no loss of life. On one of these occurrences, the colliding vessel passed under the scow, and carried off the dome with it. The dome was shortly after recovered, having lost fourteen out of nineteen of the drilling-tubes. Nothing but the overhang of the scow has hitherto saved it from being sent to the bottom, and it is quite evident that a vessel, proof against ordinary collisions, is indispensable to the work of cleaning out the obstructions in East River and Hell Gate.

For the reasons furnished in this report, I ask an appropriation of $600,000, to be devoted to the completion of the tunnels and galleries at Hallett's Point, to the work of the drilling-scow, and to the preliminary operations for the removal of the Gridiron.

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§ 3.

THE IMPROVEMENT OF THE PASSAIC RIVER, BETWEEN NEWARK AND PASSAIC.

An appropriation of $25,000 has been made for this work. No disbursements were made under this appropriation during the fiscal year ending June 30, 1872.

The amount appropriated will be devoted to the improvement of

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Belleville Bar, by dredging a channel 75 feet wide and 7½ feet deep, and depositing the rock thus obtained upon one side of the channel.

A detailed survey, which was necessary before advertising for proposals, has been made of Belleville and Rutherford Park Bars.

In order to extend the improvement to the upper portions of the river, it would be necessary to remove obstructions to navigation at Rutherford Park Bar, Holsman's Bar, and other small reefs and bars as far up as Passaic.

The amount asked to be appropriated for these items, for the fiscal year ending June 30, 1874, is $44,000.

The scale of improvement is that recommended in my report of February 7, 1872, modified only as to quantities by the detailed surveys just made.

S 4.

IMPROVEMENT AND REMOVAL OF ROCKS IN PORT CHESTER HARBOR, NEW YORK.

An appropriation of $12,000 (approved June 10, 1872) has been made for this work. No disbursements were made during the fiscal year ending June 30, 1872.

The first operations necessary, before advertising for proposals, were a detailed survey of Salt and Sunken Rocks, which has since been finished.

The sum appropriated will be devoted to the removal of Salt Rock.

The next appropriation, if one be made, should suffice for the entire removal of Sunken Rock, which has been estimated at $59,000.

S 5.

IMPROVEMENT OF RONDOUT HARBOR.

An appropriation of $10,000 (approved June 10, 1872) has been made for this work. No disbursements were made during the fiscal year ending June 30, 1872.

It is designed, under proposals already furnished after public advertisements, to commence the construction of the north dike, and finish a portion thereof of about 563 feet in length.

It is obvious that, with small appropriations, sufficient only for the construction of short lengths of dike, the channel every season will change its position, and require a new outlay of money for dredging. Hence the sole economical mode of operating is to construct the north and south dikes, in one season's work, to lengths sufficient at least to define the direction of the new channel, and thus to make one dredging suffice.

I therefore estimate $104,000 for the north and south dikes and for dredging, which I respectfully ask to be appropriated in one sum.

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S 6.

SURVEY OF PASSAIC RIVER, NEW JERSEY.

ARMY BUILDING, NEW YORK, *February* 6, 1872.

GENERAL: I have respectfully to transmit tracing of general map of Passaic River from Newark to Rutherford Park, including bar of that name, and five sheets of obstructions, more in detail. The survey embraces a length of river of about six miles.

Three tide-gauges were observed: No. 1, at Rutherford Park bridge; No. 2, at the chemical works; and No. 3, at Newark; and the mean rise and fall of tides were respectively 3.34 feet, 3.40 feet, and 4.61 feet.

By the Coast Survey there appears to be but 7 feet of depth at mean low water at the mouth of the river, and this gives the practical limit of improvement.

Middle Bar, opposite Mount Pleasant Cemetery, Newark; Belleville Bar, at mouth of Second River; and Rutherford Park Bar, constitute the principal obstructions. Besides these are several minor defects—Point House Rock, a bowlder and projections of gravelly shoals into the channels at the Newark water-works and Perry's Dock.

Middle Bar.—The preservation of channel to a depth of 7 feet, and width of 200 feet at mean low water, would require some dredging, but principally a long dike. This dike is projected as parallel to the curve formed by the extremities of the most projecting docks. Removal of Point House Rock would belong to this reach.

Belleville Bar.—This being composed largely of bowlders, would require dredging to the entire depth of 7½ feet, and width of 150 feet. A dike is considered probably necessary to maintain this channel.

Newark Water-Works.—Dredging off point of gravelly shoal.

Perry's Dock.—The same.

Rutherford Park Bar.—Dredging bar to depth of 6 feet and width of 100 feet, and diking.

ESTIMATE.

Dredging Middle Bar, 4,370 cubic yards	$1,311 00
Dike from Shoe Factory Wharf to Midland Railroad bridge, 8,830 feet long	93,774 00
Removal of Point House Rock	300 00
Dredging Belleville Bar, 20,000 cubic yards	40,000 00
Diking, 3,600 feet long	38,232 00
Dredging at Newark water-works, 1,334 cubic yards	2,330 00
Dredging at Perry's Dock, 622 cubic yards	1,090 00
Dredging at Rutherford Park Bar, 12,222 cubic yards	20,000 00
Diking, 6,250 feet long	54,312 00
	251,349 00

The most important in the list of improvements set down above are Middle Bar and Belleville Bar, the last rather the most urgent.

The country to be benefited by the improvement of the navigation of the Passaic is improving very rapidly, and is already largely engaged in manufacturing. The principal places to be benefited by the contemplated improvement would be Newark, Belleville, Passaic, Dundee, and Paterson.

Above the turnpike bridge, at Rutherford Park, the tide flows to Dundee Dam, a distance of about five and one-half miles, where the rise and fall is reported to be 2½ feet.

The obstructions in the upper part of the river are Holsman's Bar,

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300 feet wide, having a depth of 3½ feet at low water, and six other small reefs and bars, having a depth of about 4 feet at low water. With the exception of these, there is a depth of 6 feet to Passaic, the head of navigation. Barges drawing 6 to 6½ feet come down the river from Passaic.

The above details of the upper reaches come from the most experienced pilot of the river, and are sufficient to furnish a practical idea of the obstructions there found, and of the cost of removing them. The proportion of funds allotted to the Passaic River was exhausted by the surveys and maps furnished with this report.

It will be found, however, that the survey of the portion omitted would have no practical bearing upon the subject of the improvement of the Passaic River at the present time, nor until the lower reaches have been perfected and the probable results upon the navigation of the upper reaches ascertained.

The absolute levels of low water at Newark, the chemical works just above Belleville Bar, and at Rutherford Park, were respectively 0, 1.21 feet, and 1.48 feet.

The removal of Belleville Bar will lower the level of low water in the section between it and Rutherford Park Bar probably 8 inches.

The removal of Rutherford Park Bar will in like manner lower the level of low water above it, and so on of the other bars.

Hence the improvement should be commenced below and worked upward, the removal of each bar being the subject of careful study as to its effects upon the depths of water above.

The Passaic River presents the features of a succession of pools, the depths in which depend upon the frequent bars or dams extending entirely across the bed, thus keeping up the levels at low water higher than they will be after the improvements are finished.

The cost of removing obstructions above Rutherford Park bridge would be between $50,000 and $60,000.

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

ARMY BUILDING, NEW YORK, *February* 7, 1872.

GENERAL: In addition to the report of the 6th instant upon the subject of the Passaic River, which was intended to embrace the necessary works and estimate for thorough improvement of the channel, it seems proper to present my views upon the extent and cost of operations calculated to effect a partial remedy at present much needed by the business interests of the cities and towns contiguous to this stream.

It will be necessary to retain the dike projected for the improvement of the reach termed in that report the "Middle Bar," and extending from the Spool Factory Wharf to the Midland Railroad bridge.

The cost of the improvement of Belleville and Rutherford Park Bars may be much decreased by omitting the dikes, which are only of probable necessity, and by decreasing the width of dredged channels at the former place to 75 feet, and at the latter to 50 feet.

In like manner the width of dredging through the upper bars may be decreased to just sufficient to permit the passage of one boat.

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There is no doubt that such partial improvement would prove a great relief to navigation, while, from the fact that the narrow channels now recommended would not materially decrease the depth at low water of the pools above the present bar, it would be entirely safe to carry on the whole work at the same time.

I may add likewise that all of the bars, as far as known, except Middle Bar, being composed mainly of bowlders and loose stone and gravel, the *débris* from the dredging might be deposited along side of the channel and serve to mark it and preserve it from filling.

ESTIMATE.

Middle Bar, dredging	$936 00
Middle Bar, diking	66,375 00
Belleville Bar, dredging	15,501 00
Rutherford Park Bar, dredging	14,112 00
Holsman's and small bars above, dredging	12,000 00
Contingencies	15,000 00
	123,924 00

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

S 7.

SURVEY OF PORT CHESTER HARBOR, NEW YORK.

ARMY BUILDING, *New York, December* 28, 1871.

GENERAL: I have respectfully to forward chart of Port Chester Harbor, New York. This harbor forms the outlet of Byram Creek into Long Island Sound, and is situated on the boundary between the States of New York and Connecticut. The town of Port Chester, not represented upon the chart, is on Byram Creek, about one and a half miles from its mouth. The mean rise and fall of tide in Port Chester Harbor is 7.43 feet.

The most obvious improvements are the removal of "Sunken Rock," lying directly in the entrance to the harbor, and of "Salt Rock" in Byram Creek, in the path of vessels going up to Port Chester.

A breakwater from Byram Point, of the plan and section represented in the chart, would be of considerable service to the vessels trading in this locality.

It is understood that Port Chester Harbor is not a harbor of refuge for vessels in general navigating the sound, and the advantages of the breakwater would be chiefly confined to the local trade.

Herewith is appended copy of information as to the trade and commerce of Port Chester, furnished by the Hon. Jared V. Peck, of that locality.

ESTIMATE.

Removal of sunken rock:	
To 11 feet at mean low water, 1,474½ cubic yards	$58,980
Removal of Salt Rock:	
To 9 feet at mean low water, 316.3 cubic yards	12,652
Breakwater at Byram Point, 400 feet long, 13 feet above mean low water, constructed of stone-facing and concrete-filling	25,000

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Two beacons, with lights, to mark Mansersing Reef and Captain's Rock, (the latter outside the harbor, and not represented upon this chart,) are considered important elements in the improvement of this harbor.

The survey was conducted by Mr. Julius H. Striedinger, civil engineer.

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

PORT CHESTER, *November* 1, 1871.

The number of trips up and down the Byram River, to and from Port Chester, a year. 760. Amount of tonnage of these vessels, 48,500 tons. Cargoes of these vessels, up and down, 340. Value of the cargoes, $1,800,000. Internal revenue collected in the neighborhood cannot be ascertained here. Collection district in which the river is situated, tenth New York.

Manufactures which depend upon the river for supply and for exports, viz: One iron foundery, 10,000 tons of iron and coal used per year, one of the largest in the United States; 1 screw-bolt manufactory, also one of the largest in the United States; 1 woolen manufactory for the manufacture of cloth, &c.; 1 edge-tool and wagon iron-work manufactory; 2 planing and saw mills; 1 marble-factory; 1 gas-factory; 3 flouring-mills; several other small factories, doing business with the city of New York.

The above estimate is underrated rather than over, and, with proper facilities, would be immediately increased.

The railroad draws off a large quantity of freight, owing to the want of good water communication.

With great respect,

JARED V. PECK.

S 8.

SURVEY OF RONDOUT HARBOR, NEW YORK.

ARMY BUILDING, *New York, January* 25, 1872.

GENERAL: I have respectfully to forward a chart of Rondout Harbor, Hudson River. The survey was made in the fall of 1871. I will preface the report upon this subject by a description of the locality and by a brief sketch of the changes, the result of artificial works, which have affected the outlet of the creek and harbor of Rondout.

The extent of the tidal basin of the creek is from Crane's Dock to the stone dam at Eddyville, a distance of three miles. The dam was built for milling purposes, upon a natural fall in the creek, during the earliest settlement of the State. The Delaware and Hudson Canal Company perfected the dam, and remodeled it to its present shape in 1850. It is used as a waste-weir for the canal, discharging the freshet waters into the creek.

Kingston Point was originally an island, between which and the west shore lay a meadow or flat 1,100 feet wide, over which was a depth of 3 feet at ordinary high tide.

The island in 1803 was connected with the west shore by a turnpike, excluding the flow of the tide across the low level.

The first, or most northerly pier, at Kingston Point, was built for the uses of a ferry. The lower was constructed in 1810, projecting 70 feet into the river, and extended to 260 feet, its present length, in 1840.

Protection Dock was built in the spring of 1867 by a company in op-

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position to the canal company. A compromise was finally made, and the enterprise has remained in *statu quo*.

The steamboat company of Rondout in 1870 dredged a channel, 14 feet deep, from Crane's Dock, through the shoal, to the deep water of Hudson River, in the direction of A B.

The cut has, in this short period, generally shoaled by deposits from the creek and river, and affords at the present time a clear draught of but 7.3 feet at low water.

There are not in my possession maps prior in date to those of the Coast Survey of 1863 and 1868, and of these the latter only is in sufficient detail to be valuable for comparison. It is stated, however, by inhabitants who remember the facts, that formerly an 8-foot channel, starting from the neighborhood of Kingston Point, crossed the northern shoal, and that the principal entrance to the creek was without difficulties. In 1866 the outlet, as defined by the Coast Survey, gave a depth rising 9 feet at low water. The present survey shows a great filling of the outlet, which deep dredging, only a year ago, has not availed to keep open to a greater depth than 7.3 feet at low water.

Since 1868 there has likewise been an increased projection of the 9.12, 15, and 18-foot curves into the channel of the Hudson.

From these facts, and from viewing the course of the river upon the charts, I am led to the opinion that the action of the long pier and Protection Dock has been prejudicial to the outlet of the creek, by favoring deposits upon the shoals and in the channel, and that the removal of a portion of the long pier and of the whole of Protection Dock would be beneficial by checking the further growth of the shoals, and even by diminishing their present extent.

Conjointly with this, I would recommend the construction of parallel dikes, curved in plan, the north dike commencing at Crane's Dock, and the south at the upper part of the canal-boat reservoir.

The distance apart of these dikes has been determined from the cross-sections of the creek above, where it is confined between parallel wharves, and has been calculated for a depth of about 13 feet at mean low water. The branch dike running to the northward would not be as long, probably, in this case, as is represented in the chart.

The length of the north and south dikes would depend upon their observed effects in the removal of the bar, as they are gradually advanced from their starting-points. They should be made as short as possible, not merely with a view to economy, but because it is evident that in proportion to their development they would tend to consolidate and render permanent the existing shoals to the northward and southward by withdrawing these from the action of the currents.

The discharge of the outlet of the creek should be in a direction as nearly as possible coincident with the ebb of the river; such a direction also being most advantageous for the entrance of the flood. Another direction of the dikes, leading more directly across the current of the river, would, by interference of currents, tend to the extension of the shoal beyond its present limits.

The dikes, as drawn upon the chart, represent their plan and lengths upon the supposition that the long pier and Protection Dock may not be removed, and the estimate is made for this case. It is evident at once that the north and south shoals, to their full extent, would be consolidated and rendered permanent by such a development of dike.

The branch dike, to the northward, would not necessarily be of the length or constructed in the exact direction given in the chart, but has been so projected to give the extreme length and cost.

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ESTIMATE.

North dike, 748 yards long	$41,600
Branch dike, 604 yards long	34,400
South dike, 1,277 yards long	59,600
Dredging a channel 3,000 feet long, 100 feet wide, and 14 feet deep at mean low water, 48,000 cubic yards, at 30 cents	14,400
Contingencies and engineering, 15 per cent	22,500
	172,500

This estimate would suffice for the construction of the works of improvement by either plan.

A large number of vessels coming to Rondout for cargoes are obliged to load and unload outside the bar at additional cost.

The trade and importance of Rondout have already been described in my report of February 16, 1869, and it is only necessary now to state that these have not since diminished.

The improvement of this harbor would not be for the benefit merely of local commerce—a large number of vessels from all parts of the country, as well as foreigners, visit this port.

The survey and drawings were made by Mr. F. Von Eglofstein, civil engineer, and valuable information was collected by him.

The survey was under the general charge of Mr. Julius H. Striedinger, civil engineer.

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

S 9.

SURVEY OF EAST CHESTER CREEK, NEW YORK.

ARMY BUILDING, NEW YORK, *January* 19, 1872.

GENERAL: I have respectfully to transmit four sheets of drawings embodying the results of the survey of East Chester Creek, New York.

The survey embraced the course of the Creek between a point 1,200 feet below Pelham bridge to the stone bridge near Mount Vernon.

The creek is a shallow, sluggish stream, winding its tortuous channels through banks of marsh-land, the general level of the banks being that of mean high water.

The deposits, which have caused the shoaling of the channel, are very fine, and this fact shows the absence of currents of eroding power.

Three tide-gauges, the positions of which are marked upon the map, were observed; No. 1 above Lockwood's, No. 2 above Town Dock, and No. 3 below Pelham bridge. The mean rise and fall at Nos. 2 and 3 was 7.14 feet and 7.13 feet respectively, and at No. 1 but 5.09 feet. The absolute levels of high and low water at Nos. 2 and 3 are practically the same. At No. 1, however, the levels of high and low water are respectively 0.58 foot and 2.62 feet higher. The distance between Nos. 3 and 2 is 9,300 feet, and between Nos. 2 and 1, 9,400 feet.

These facts indicate some unusual obstruction to the tides between Nos. 2 and 1, and a glance at the map will show the cause—in the construction across the channel of a solid roadway, broken only by a

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trifling opening of 25 feet to admit the tides. As if this were not enough, the reversed arch between the abutments of this sluice-way is held at such a high level as to be out of the water at a period a little after half ebb.

These circumstances have been probably a prominent cause of the dwindling of the creek above Lockwood's, and, by the consequent loss of tidal flow, the cause also of the shoaling of the water from Lockwood's down.

Pelham bridge is a new structure, just completed, and I have been told that the former bridge at the same point obstructed the tidal flow, but as it has not been found possible to obtain a plan or reliable description of the old bridge, I could not vouch for the accuracy of the statement.

The statement of those acquainted with the matter is, that freight and expenses by vessels is enhanced by the delays incident to the restricted depth of water, and by the cost of hauling from Town Dock, the general point of discharge, to the village, a distance of over a mile.

I am informed, likewise, that the reputation of the creek as a navigable stream is so poor that it is difficult to engage a vessel for a second trip. As a necessary consequence, much freight comes by rail, and at rates peculiar to such a mode of transportation.

Such a state of things tends to retard the development of the manufacturing and other industry of the neighborhood, and hence the desire of the residents for an improvement of navigation.

The effect of the gradual silting of this creek has been not only to diminish the navigable depth, but also to convert into marsh-land—now generally at the level of high water—large spaces, which cannot be reconverted to the objects of a tidal reservoir, except by a large outlay of money.

To obtain a current velocity capable of maintaining a channel of 9 feet in depth at mean low water, as some of the residents desire, would involve the necessity of purchasing a large tract of marsh-land above Lockwood's, and excavating the same to an adequate depth to serve as a tidal reservoir, and of confining the channel from Lockwood's to Pelham bridge by an extensive system of dikes. The estimated cost of such operations is $1,646,000.

To obtain a depth, however, of 11 feet at mean high water would require a reservoir less extensive, but the same system of dikes would be necessary. The cost of these operations as estimated would be $731,000.

There remains to be discussed the question of slackwater navigation, the lock being placed at a contraction of the creek above Goose Island. This project would involve likewise the necessity of the construction of a tow-path from the lock upward, and of dredging the channel below to Pelham bridge. The estimated cost to secure a draught of 7 feet is $300,000. But there is no certainty that constant dredging to keep the lower channel open would not be necessary, while the formation of new shoals below Pelham bridge would probably result.

I likewise transmit statement of Messrs. Martin, Rankin, and Van Gaasbeck as to the commerce, &c., of East Chester Creek.

The surveys and examinations were under the charge of Mr. Julius H. Striedinger, civil engineer.

Respectfully submitted.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

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EAST CHESTER, N. Y., *November* 20, 1871.

DEAR SIR: In answer to your note of inquiry in regard to the commerce of East Chester Creek and Harbor, and the manufactures, &c., in its immediate vicinity, we would respectfully submit the following:

Schedule.	Vessels.	Trips.	Tonnage.	Cargoes.	Total value.
A	14	28	200	Coal	$30,000
	8	16		Brick	4,000
	2	4		Wood	700
B	10	20		Lumber	25,000
	5	10		Brick	2,500
	1	2		Coal	400
C	12	24	220	Lime	15,000
	1	2	60	Brick	300
D	14	28	120	Coal	11,400
	5	10		Wood	600
	Steamer	Runn'g weekly.		$2,000 per trip	100,000
E	6	12	200	Flagstone	8,000
F	100	200	130	Macadam	25,000
G	14	28	230	Coal	20,000
	14	28		Timber, &c	36,000
	8	16	100	Lime, &c	2,400
H	7,4 mos.	14	220	Coal	11,000
Freight collected at Mount Vernon depots during a year, $28,800; estimated to be 3 per cent. of value of merchandise carried, $960,000; and it is estimated that not less than two-thirds of this amount would be brought by water if vessels could approach within reasonable distance of the village; say					640,000
Manufactures.—Tuckahoe marble, (formerly shipped by the natural outlet, East Chester Creek,) in value estimated at					500,000
Glue, axles, cutlery, doors, sashes, blinds, rye whisky, beer, &c., which would nearly all go by water, if facilities were afforded, not less than					300,000
Timber, lumber, coal, &c., brought into our village and vicinity from Yonkers, New Rochelle, and Harlem River by teams, at an average cost of about $3 per load; value estimated at about					70,000
Timber, lumber, coal, &c., brought into our village and vicinity by railroad from New York City, at a cost of $15 per car-load of 8 tons, for which we have no reliable data for estimating, but suppose it would amount to, probably, $100,000.					
Total					1,790,563

We would further state that the prices of lumber, coal, stone, &c., are always at least one dollar higher (per ton or load) than in any good port within one hundred miles of New York City, and that manufactures, in consequence of these high freights, do not thrive proportionately to our otherwise natural advantages and favored location.

The proposed improvement is in collection district No. 10, and the internal revenue collected in that district for the fiscal year ended June 30, 1871, is $763,856.43.

The increase of population in this neighborhood is equal to, if not greater than, that of any other part of the State of New York.

The figures in foregoing schedule refer, in every case, to the business of one year, except under "H."

EDWARD MARTIN,
Supervisor of the Town of East Chester.
JNO. C. RANKIN.
B. VAN GAASBECK.

General NEWTON.

ARMY BUILDING, NEW YORK, *April* 3, 1872.

GENERAL: In reply to a resolution of the House of Representatives of March 2[illegible] 1872—

"On motion of Mr. Potter—

"*Resolved*, That the Secretary of War be requested to report to this House the cost of removing so much of the obstructions in the East Chester Creek as lie between the points marked on the map referred to in the report of the Chief of Engineers, dated February 14, 1872, as tidal-gauges Nos. 1 and 2, so far as to afford the same depth of water above the station No. 1 as now prevails below it"—

I have respectfully to state that the removal of obstructions between Nos. 1 and 2 will not, in my opinion, without extending the work of improvement (as stated further on) beyond and above No. 1, exercise much influence above this point. To fulfill, however, the intention of the resolution, as understood by me, I would propose a narrow cut commencing near Lockwood's, extending up the Creek 4,000 feet, and terminating at a

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point about 1,500 above tide-gauge No. 1. The object of this cut is to get rid of the sharp curves at present existing in this locality.

At the upper end of the cut it will be necessary to locate and excavate a tidal basin, with the object of keeping the cut open by means of the currents of the ebb and flood.

The cut where it crosses the present channel must be diked, and the concave bank be revetted with rubble.

As it is necessary for the cut to cross the Boston post-road at a point different from the present crossing, where there is a bridge, it may be necessary to secure the right of way, as also to construct a draw-bridge over the new channel. Neither of these are estimated for. It may be considered proper that the persons benefitted should take this part of the operations upon themselves. The draw will not be long, as the width of the cut is designed at 64 feet only.

ESTIMATE

Basin, purchase of site, 18 acres, at $150	$2,700
Excavation to level of mean low water, 200,000 cubic yards, at 40 cents	80,000
Excavation of cut, 60,000 cubic yards, at 40 cents	24,000
Diking and revetting banks of cut	12,000
Engineering and contingencies	17,805
Total	136,505

The excavation of the cut alone, with dikes and revetment and contingent expenses, would cost about $41,400; but this work, although it would give immediate relief by affording a draught up to the village of Mount Vernon of 9 feet at mean high water, should not be undertaken without the intention further of constructing the tidal basin, and of completing the project herein recommended.

Very respectfully, general, your obedient servant,

JOHN NEWTON,
Lieutenant-Colonel of Engineers.

General A. A. HUMPHREYS,
Chief of Engineers, Washington.

APPENDIX T.

ANNUAL REPORT OF MAJOR G. K. WARREN, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDED JUNE 30, 1872.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, August 31, 1872.

GENERAL: I have the honor to submit the annual reports upon the works of survey and improvement specially under my direction during the fiscal year ending June 30, 1872, together with an outline of operations from June 30 to present date, relating to these works and to those that have come under my charge since that date.

The list is as follows:

1. Completing maps and report on bridges across the Mississippi River between Saint Paul and Saint Louis, and on improvement of the river.
2. Completing maps and report on improving the Wisconsin River.
3. Completion of map of battle-field of Gettysburg.
4. Improvement of Hyannis Harbor, Massachusetts.
5. Improvement of Wareham Harbor, Massachusetts.
6. Improvement of Edgartown Harbor, Massachusetts.
7. Improvement of Taunton Harbor, Massachusetts.
8. Improvement of Pawtucket (Seekonk) River, Rhode Island.
9. Improvement of Providence River, Rhode Island.
10. Survey of Providence River, Rhode Island.
11. Survey of Wickford Harbor, Rhode Island.

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12. Survey of Newport Harbor, Rhode Island.
13. Construction of harbor at Block Island, Rhode Island.
14. Improvement of Pawcatuck River, Rhode Island and Connecticut.
15. Survey of Stonington Harbor, Connecticut.
16. Improvement of Thames River, Connecticut.
17. Survey of Niantic River, Connecticut.
18. Improvement of Connecticut River below Hartford, Connecticut and Massachusetts.
19. Improvement of Connecticut River above Hartford, Connecticut and Massachusetts.
20. Improvement of New Haven Harbor, Connecticut.
21. Survey of Milford Harbor, Connecticut.
22. Improvement of Housatonic River, Connecticut.
23. Improvement of Bridgeport Harbor, Connecticut.
24. Improvement of Westport Harbor, Connecticut.
25. Survey and improvement of Norwalk Harbor, Connecticut.
26. Survey and improvement of Huntington Harbor, New York.
27. Improvement of Port Jefferson Harbor, New York.
28. Improvement of Peconic River, New York.

The above works, from No. 4 to No. 7, inclusive, are reported upon by Colonel George Thom, United States Engineers, up to date of June 30, 1872.

For convenience of reference, I will give here the estimates of funds required to be appropriated for continuing or completing works already commenced during the fiscal year ending June 30, 1874. Special estimates will be made in a future report for works of improvement at points where surveys were directed by the act approved June 10, 1872, as soon as the surveys are completed. Estimates in reports of surveys heretofore presented to Congress, and for places where no appropriations have been made, are not repeated in this abstract.

Estimate of funds required for the fiscal year ending June 30, 1874.

For improvement of Hyannis Harbor, Massachusetts	$10
For improvement of Wareham Harbor, Massachusetts	10,0
For improvement of Taunton River, Massachusetts	20,0
For improvement of Pawtucket River, Rhode Island	1,0
For improvement of Providence River, Rhode Island	10,0
For harbor at Block Island, Rhode Island	100,0
For improvement of Pawcatuck River, Rhode Island and Connecticut	15,0
For improvement of Connecticut River, Connecticut	40,0
For improvement of New Haven Harbor, Connecticut	25,0
For improvement of Housatonic River, Connecticut	20,0
For improvement of Bridgeport Harbor, Connecticut	6,0
For improvement of Norwalk River, Connecticut	20,0
For improvement of Port Jefferson Harbor, New York	2,0
For improvement of Peconic River, New York	1,0
Total	350,0

A detailed report for each work separately is sent to accompany this, arranged in the order named above in the first enumeration of them.

Respectfully submitted.

G. K. WARREN,
Major Engineers, Brevet Major-General United States Army.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

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COMPLETING MAPS AND REPORT ON BRIDGES ACROSS THE MISSISSIPPI RIVER, BETWEEN SAINT PAUL, MINNESOTA, AND SAINT LOUIS, MISSOURI, AND ON IMPROVEMENT OF THE RIVER.

During the year ending June 30th the maps of surveys made on the Mississippi River in the years 1866, 1867, 1868, and 1869 have been essentially completed, and a copy made on tracing-cloth and sent to the office of the Chief of Engineers.

The report on the improvement is mostly yet to be written; that in regard to the bridges has been partly completed.

The maps are as follows:

The map of the Mississippi River from the mouth of the Minnesota River to the mouth of the Ohio, on a scale of 2 inches to the mile, in 22 sheets.

From the Falls of Saint Anthony to the outlet of Lake Saint Croix, 10 sheets, on a scale of 200 feet to an inch.

Sheet No. 11, mouth of Cannon River, scale 400 feet to an inch.

Sheet No. 12, Wacouta Channel, Lake Pepin, scale 400 feet to an inch.

Sheets Nos. 13 to 16, (inclusive,) from Chippewa River to Winona, scale 400 feet to an inch.

Sheets Nos. 13′ and 16′, resurveys of portions, scale 400 feet to an inch.

Sheet No. 17, at Trempeleau Bar, scale 400 feet to an inch.

Sheet No. 18, at mouth of Black River, Wisconsin, scale 400 feet to an inch.

Sheet No. 19, at La Crosse, Wisconsin, scale 400 feet to an inch.

Sheet No. 20, at Coon Slough and Raft Channel, scale 400 feet to an inch.

Sheet No. 21, at Lansing, scale 400 feet to an inch.

Sheet No. 22, at Prairie du Chien, scale 400 feet to an inch.

Sheet No. 23, at Guttenberg and Cassville Chutes, scale 400 feet to an inch.

Sheet No. 24, at Dubuque, Iowa, scale 400 feet to an inch.

Sheet No. 24′, at Dubuque, Iowa, scale 400 feet to an inch.

Sheet No. 25, at Clinton, Iowa, scale 400 feet to an inch.

Sheet No. 26, at Rock Island, Illinois, scale 400 feet to an inch.

Sheet No. 27, at Burlington, Iowa, scale 400 feet to an inch.

Sheet No. 28, at Keokuk, Iowa, scale 400 feet to an inch.

Sheet No. 29, at Quincy, Illinois, scale 400 feet to an inch.

Sheet No. 30, at Hannibal, Missouri, scale 400 feet to an inch.

Sheet No. 31, at mouth of Missouri River, scale 400 feet to an inch.

COMPLETING MAPS AND REPORT ON IMPROVING THE WISCONSIN RIVER.

These maps have all been completed, and a copy made on tracing-cloth and sent to the office of the Chief of Engineers.

The river measurements have all been completed, and nearly all the estimates for different methods of improvement revised. The report has been in a great measure written up, and a comparison made of the Wisconsin River with an improved river in France. It is expected that the whole report will be completed this winter.

The following is a list of finished maps:

Two sheets of the whole river from Portage to its mouth, on a scale of 2 inches to the mile.

Twenty-four sheets of the river from Portage to its mouth, scale 200 feet to the inch.

One sheet, on a scale of 400 feet to the inch, showing a cross-section of the valley at Portage City, Wisconsin.

Three sheets of cross-section of the valley at different points between Portage and mouth of the river.

One sheet showing the three railroad-bridges on a scale of 200 feet to the inch.

One sheet giving a profile of the river longitudinally from Portage to its mouth.

MAP OF BATTLE-FIELD OF GETTYSBURG.

During the past year this map was put in the hands of an engraver, Mr. Julius Bien, of New York. It embraces a tract of country six miles square, and, in order to print it from a single stone, he reduced it from a scale of 800 feet to an inch to one of 1,000 feet to an inch. Its completion was delayed by several ineffectual attempts to so shade it as to produce a good relief to the hills and inequalities of the field. The difficulty has been at last overcome, and the engraving is now about finished. Proof-sheets will be forwarded at no distant day.

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T 1.

IMPROVEMENT OF PAWTUCKET (SEEKONK) RIVER, RHODE ISLAND.

Under the appropriation of $7,000, made by the act approved March 3, 1871, proposals for dredging were advertised for, and work begun, as stated in my last annual report, dated August 31, 1871, already published.

The work, under the appropriation of $8,000, approved July 11, 1870, was mostly confined to the part above Dunnell's Wharf, where a channel 75 feet wide and 6 feet deep was excavated; but the $8,000 was not all expended during the fiscal year ending June 30, 1871, for which it was first made, a considerable portion being on hand and re-appropriated by the act approved March 3, 1871, which gave an additional appropriation of $7,000 for the fiscal year ending June 30, 1872. When the work was planned under this last appropriation act, it was determined to have the channel made *seven* feet deep at mean low water, instead of *six* feet, and to begin working at the lowest part of the river that had a less depth than 6 feet at mean low water, and, while at it, excavate to a depth of 7 feet at such places. Proceeding in this way, the whole appropriation became exhausted on the 18th of November, while there was yet a space along the channel about 1,500 feet long, over which there was a depth of but 5½ feet at mean low water. The mean rise of the tide being 5 feet, vessels drawing 10½ feet could pass up at high water.

To complete the channel up to Pawtucket, 75 feet wide and 7 feet deep, was estimated to require the removal still of 35,000 cubic yards of sand and mud, at a cost of $15,400. Recent examinations show that the excavated channel is liable to fill up again from silt brought down the stream, and this estimate will have to be somewhat increased, and something done annually to keep the channel open.

The appropriation approved June 10, 1872, for the present fiscal year, amounts to $10,000.

Proposals for doing this work were duly advertised, the following being the specifications:

This appropriation will be expended in dredging between Spring Run and Dunnell's Wharf, so as to give a channel 75 feet wide, and 7 feet deep, at mean low water. The least depth in this distance is now about 5½ feet at mean low water.

The material to be excavated is mud, sand, and fine gravel. It can be dumped at all times of tide within a distance of from one-half mile to two miles; a portion of it may be dumped on contiguous flats at high water only. The tide rises 5 feet.

Proposals will state the price per cubic yard, measured in the scows, for dredging and removing the material. Care must be taken not to confound *Pawcatuck River* with this one.

The only bidder was Mr. E. M. Payn, of Albany, New York, at 32½ cents a cubic yard, and a contract has been made with him for doing the work. He began work August 8, 1872, and is making good progress. Mr. Payn was the former contractor for the work, at 33 cents per cubic yard.

An appropriation of $10,000 is recommended for continuing this work during the fiscal year ending June 30, 1874.

Pawtucket River is in the Providence collection-district, where the revenue collected during the fiscal year ending June 30, 1872, amounted to $222,065.36. The nearest port of entry is Providence, situated at the junction of the Providence and Pawtucket or Seekonk Rivers.

I append to this report that of Mr. H. A. Bentley, civil engineer, which shows in detail the nature of former expenditures, and the estimate of additional work. This is accompanied by a map in colors.

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which shows at a glance the locality of the dredging and its monthly rate of progress, which map was sent to your office by me, accompanying a report dated December 20, 1871.

Statement of funds.

Amount available July 1, 1871	$8,092 20
Amount appropriated by act of June 10, 1872	10,000 00
Amount expended during fiscal year ending June 30, 1872	8,092 20
Amount available July 1, 1872	10,000 00
Amount required for the fiscal year ending June 30, 1874	10,000 00

DECEMBER 20, 1871.

GENERAL: I have the honor to submit herewith a map of the Seekonk River, (Pawtucket River,) Rhode Island, exhibiting the condition of the channel at the close of dredging, November 18, 1871, from the exhaustion of the appropriation, with estimates for making a depth of 7 feet at mean low water, from Spring Run to Dunnell's Wharf, Pawtucket.

Dredging, under appropriation made by act approved July 11, 1870, was commenced December 10, 1870, just above Dunnell's Wharf, under superintendence of Mr. N. E. Russell, civil engineer, who made some surveys, and was suspended December 31, 1870, on account of ice. Operations were resumed April 1, 1871, under direction of Mr. John H. Dager, civil engineer, who continued in charge until relieved by me, April 29. Surveys were made from time to time by the different superintendents, as shown in the title of this map. The dredging, up to June 30, was done by Mr. Emory R. Seward, of Albany, New York, at the rate of 27 cents per cubic yard. By terms of the contract, Mr. Seward was required to deposit the material excavated on contiguous flats. To do this he used four bottom-dumping scows, two of 50 and two of 80 yards capacity, and a small steam-tug to tow them to the dumping-ground; they were then poled as near shore as possible and dumped. The dredge, a small "Osgood," with a one-yard dipper, would fill these scows in about five hours, and as they could be dumped only at or near high water, a full day's work was seldom done. Had the contractor had a greater number of scows the work would have been completed much sooner, and considerable expense for superintendence saved.

Under appropriation made by act of Congress approved March 3, 1871, a contract for dredging was made with Mr. Edgar M. Payn, of Albany, New York, at 33 cents per cubic yard.

Mr. Payn used endless-chain dredges, working in the center, and making a cut about 10 feet wide, and four scows of about the same capacity as those employed by Mr. Seward. His work being near the dumping-ground, he was enabled to pole his scows, thus saving the expense of a tug. Endless-chain dredges are not adapted to dredging where a light cut is required, because of the difficulty in moving them, and the irregular bottom they leave in any material except sand.

Amount appropriated by act approved July 11, 1870	$8,000
Amount appropriated by act March 3, 1871	7,000
	15,000
Amount of material dredged by Mr. E. R. Seward, 16,219.95 cubic yards, at 27 cents	$4,389 39
By Mr. E. M. Payn, 21,159.4 cubic yards, at 33 cents	6,982 60
Surveys, superintendence, instruments, and office expenses	3,628 01
	15,000 00

The expense of conducting this work was unusually large on account of making surveys where the channel was to be dredged, and also at the Red Bridge, where the bridge company made application to have old riprap work dredged out, and also because of the length of time over which the work was extended by dilatoriness of the first contractor. To give 7 feet of water from Spring Run to Dunnell's Wharf, Pawtucket, I estimate as follows:

From Spring Run to Swan Point, 5,000 cubic yards. The material to be removed is soft mud.

The greater part of the work lies between Swan Point and Dunnell's Wharf; the material is sand and gravel, with a depth of water varying from 5 to 6 feet; the amount of material necessary to be excavated to give 7 feet of water is 35,000 cubic

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yards; this estimate allows for all sand, &c., which would wash into the channel when digging on the sides, and for all dredging done below the required depth of 7 feet, which cannot be avoided when making light cuts.

RECAPITULATION.

From Spring Run to Swan Point, 5,000 cubic yards, at 35 cents	$1,750
From Swan Point to Dunnell's Wharf, 35,000 cubic yards, at 35 cents	12,250
Then from Spring Run to Dunnell's Wharf, 40,000 cubic yards, at 35 cents	14,000
Add 10 per cent. for superintendence, &c	1,400
Total cost of proposed improvement	15,400

Above Dunnell's Wharf no dredging is necessary at present, although the rapid filling of the channel of the river opposite Smith's Wharf, by deposits from a sewer which has an outlet in said wharf, will soon require attention.

Most of the dumping will hereafter have to be done below Butler Hospital dock, as nearly all available dumping-grounds above have been filled.

Very respectfully, your obedient servant,

H. A. BENTLEY,
Civil Engineer.

Brevet Major-General G. K. WARREN,
Major of Engineers, U. S. A.

T 2.

IMPROVEMENT OF PROVIDENCE RIVER, RHODE ISLAND.

There was no appropriation for this work during the fiscal year ending June 30, 1872.

By the act approved June 10, 1872, an appropriation of $10,000 was made for it, and on the 28th of June I advertised for proposals to do the work according to the following specifications:

Proposals will be received for widening the channel at "the Crook" on the west side. The material here is a clayey mud in which a Morris & Cummings dredge works well. The material must be deposited at a point about five miles below. Proposals will also be received for the dredging off of the sandy shoal point on the east side of the channel opposite Sassafras Point, about one mile below "the Crook," the material to be deposited about four miles below.

In both cases the price per cubic yard, measured in the scows, will be stated, and bids can be made for the whole amount of the appropriation at either place, or for half of it at each.

There is plenty of water for the use of tugs, scows, &c., at each place. No dredging to go below 14 feet at mean low water.

The mean rise of tides is 5 feet.

The only proposal received was from Thomas J. Hill, of Providence. This was to do the dredging at "the Crook" for 25 cents a cubic yard, and opposite Sassafras Point for 37½ cents a cubic yard. A contract will be made with him and the work will probably begin in October.

I recommend an appropriation of $10,000 for continuing this work during the fiscal year ending June 30, 1874.

Providence River is in the Providence collection-district, and that city is a port of entry. The revenue collected there during the fiscal year ending June 30, 1872, was $222,065.36.

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T 3.

CONSTRUCTION OF BREAKWATER AT BLOCK ISLAND, RHODE ISLAND.

The condition of this work on the 31st of August, 1871, is given in my last annual report. During the remainder of that season the progress was not as great as had been anticipated, owing to the difficulty of getting vessels to bring the stone to the island. The shallow depths and rock-obstructions, the exposed position, and distance from any secure harbor in easterly winds, caused much delay to the vessels when loaded, as they often had to lie by many days for favorable weather.

The crib for the inner harbor, on the most exposed side, was nearly completed last autumn. It was nearly all in by the end of the fiscal year, and has since been quite completed.

The contractors for riprap stone have put in during the fiscal year 6,000 tons. About 1,500 tons were put on it by days' labor in leveling it up, at the shore end, to receive the crib-work, so that there are now about 14,500 tons of stone in the main breakwater. This now extends out about 550 feet beyond the inner harbor. It is mostly complete up to mean tide-level, though it has not, in all places, the full width at the bottom originally designed, to wit, equal to the top width increased by four times its height.

The dredging of the inner basin, the construction of a wharf, and the piling for the protection of the entrance, were not completed during the last fiscal year, as first expected, but the funds were on hand available for the purpose, and this work has since begun, and will be completed this fall. Arrangements, too, have been made for removing several large bowlders that obstruct the space inclosed by the breakwater.

It has been found necessary to construct another jettee from a point on the shore, about 1,200 feet from the main breakwater, running along the crest of a bowlder-reef, on a line converging toward the main breakwater. This is mainly built of bowlders found in the vicinity. Its immediate object is to arrest the action of the heavy waves rolling in from the eastward, which, sweeping around the end of the breakwater, run along the shore toward the breakwater, abrading the bank, and causing a deposit in the sheltered angle between the breakwater and the shore. Ultimately this jettee when extended out about 600 feet, will have the effect to prevent the influx of the waves into the space behind the main breakwater, and secure a quiet surface, so that vessels will not be injured by thumping, even if run aground.

The appropriation of $50,000, approved June 10, 1872, will be mainly expended in completing and extending the main breakwater, and lengthening out the jettee to the west of it, whose object is above described.

We do not think it best now to attempt to build the superstructure to the main breakwater in the solid manner as first designed, but to raise it to the required height by using large riprap blocks. These can be replaced by the more solid superstructure, if found necessary, hereafter, when the substructure has secured a permanent bed. There will be economy in this, and greater shelter can be at once secured with the same expense.

On the 28th of June advertisement was made for proposals to furnish riprap, under the appropriation approved July 10.

The following is the specification for the work as advertised:

Ten thousand tons of riprap granite will be required in blocks averaging not

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less than one and a half tons each, and none weighing less than one-quarter of a ton. They should be as nearly cubical as practicable, the smallest dimension not being less than one-third the greatest.

About 3,500 tons will have to be distributed along the top of the part now built up to mean low water, to bring it up to mean high water, over a distance of 300 feet, the depth of water varying from 8 feet to 11 feet. The remainder will be used in extending the breakwater where there is a depth of from 11 feet to 13 feet at mean low water. The mean rise of the tide is 3 feet.

The rock can be deposited from vessels with the ordinary spar-derrick, and several vessels can unload at the same time.

Proposals should state the price per ton, placed in breakwater.

After thirty days' notice the proposals were opened, and the contract awarded to Mr. John G. Sheffield, of Block Island, at the rate of $2.19 per cubic yard.

The following is an abstract of the proposals received:

Abstract of proposals for the construction of a breakwater at Block Island, Rhode Island, received at engineer office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Granite, price per ton.	Quantity bid for.	Commenced.	Complete.	The amount of stone called for in specifications, at the price named, would cost—
John G. Sheffield, Newport, R. I.	$2 19	.....	Aug. 10, 1872	June 30, 1873	$21,900 00
Isaac Hamilton & John F. Hamilton, Portland, Me.	2 95	.....	(a)	June 30, 1873	29,500 00
Andrew W. McKee, Huntington, Long Island, N. Y.	3 17½ 3 76	6,500 tons *b* 3,500 tons *c*	Aug. 20, 1872	June 30, 1872	33,797 50
John Flannel, foot of North 13th street, Williamsburg, Long Island, N. Y. *d.*	3 19	10,000 tons	Sept. 1, 1872	June 30, 1873	31,900 00
Dawson, Tank & Co., New London, Conn.	3 20	5,000 tons *e*	Sept. 1, 1872	June 30, 1873	32,000 00
D. V. Howell, 141 Chambers street, New York City.	3 22	.....	Sept. 1, 1872	July 30, 1873	32,200 00
John Beattie, Stony Creek, Conn. *f*	3 25	.....	Aug. 10, 1872	June 30, 1873	32,500 00
C. C. Campbell, Lyme, Conn	3 75	5,000 tons	Aug. 30, 1872	June 30, 1873	37,500 00
Francis H. Smith, 121 Front street, New York City.	3 89	1,000 tons	Aug. 15, 1872	June 30, 1873	38,900 00
C. W. Campbell & Co., Lyme, Conn	4 37 3 37	3,500 tons *g* 6,500 tons *h*	Aug. 15, 1872	June 30, 1873	37,200 00

a Within ten days of acceptance of proposals. *b* At base. *c* At top.
d No certificate that guarantors are responsible parties.
e To be dumped in deep water. *f* Signature of guarantors not witnessed.
g To be placed on top of breakwater. *h* To be placed at end of breakwater.

The breakwater is built on the line designed by the board of engineers as furnishing a harbor for local purposes, and has already reached the Five-foot Rock, (Blue-bird Rock.) We find, however, that there is from 1½ to 2 feet less water at mean low water than was shown by the first survey, and the breakwater will have to be extended further than was recommended by the board, in order to secure the same shelter for vessels. The amount of stone estimated by the board is consequently much too great for their proposed length of substructure, so that the same estimate as to amount of stone and cost will cover all the extension required. This will be about 300 feet beyond the terminal point originally fixed upon.

There seems scarcely room for a doubt that when this local breakwater and harbor is established its utility will demonstrate the necessity for the larger harbor which has been contemplated.

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After this year the work can be carried on with much greater facility than heretofore, and I therefore recommend the appropriation of $100,000 for the fiscal year ending June 30, 1874. This, together with what has already been appropriated, will amount to $255,000, and the original estimate for the work was for $372,000.

Block Island is in the Newport collection-district. There is no duty collected at the island. The value of the harbor publicly is as one of refuge to the coasting-vessels. There is a light-house on the north end of the island, and another is to be erected on the south end of it. I transmit herewith the report of Mr. J. P. Cotton, civil engineer, who has charge of this work.

Statement of funds.

Amount available July 1, 1871	$82,686 50
Amount appropriated by act of June 10, 1872	50,000 00
Amount expended during fiscal year ending June 30, 1872	54,002 05
Amount available July 1, 1872	78,684 45
Amount required for fiscal year ending June 30, 1874	100,000 00

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, August 31, 1872.

GENERAL: I have the honor to submit the following report of operations in the construction of a breakwater at Block Island, Rhode Island, since I, by your direction, took charge of it, in April, 1871.

In April, 1871, I made, under your direction, a plan and estimate for a crib-superstructure, to be built upon the substructure already completed, out several hundred feet from the shore, this crib-work to commence at the shore and extend out to 5 feet of water at mean low water; to the west of this, and parallel to it, another crib was to be built out to the same depth of water. From the outer end of these cribs wings were to be built toward each other, leaving an opening of about 80 feet. This inclosure, which it was proposed to dredge out to a depth sufficient to allow coasters of 7 feet draught to enter at all times of tide, contains a space about 70,000 square feet of safe anchorage where vessels can moor safely in the worst storms.

On the 29th of April, 1871, advertisements were made asking for proposals for furnishing the necessary timber, bolts, &c., &c. On the 8th of June, 1871, the contract for timber was awarded to Messrs. Finch, Engs & Co., of Newport, Rhode Island; for bolts, to Messrs. R. S. Place & Co., of New York; and for granite, to Mr. C. C. Campbell, of New York.

The timber required was of such length and size that none could be found in stock; the first cargo was sawed and shipped at Bangor, Maine, by the 15th of July, and was landed on the island on the 1st of August. On the 11th of August Messrs. R. S. Place, & Co., of New York, delivered all the bolts required for the work. On the 22d of August the first timber was put in position in the crib, and from that time to the 1st of October, advantage was taken of favorable weather and tides to put in as much timber as possible. The work of filling the crib and building the protecting wall was kept well up with the work on the crib. Up to this (October 1) the contractor for furnishing granite for the substructure of west crib and wings had not been able to get a light-draught vessel for this work. During October much pleasant weather could not be improved for want of this stone.

In the latter part of October it became evident that the building of the west crib would have to be postponed until this season. I then put all the force at our command to hauling bowlders found on the island to the shore and scowing them out for the substructure of the wing of the east crib. The weather during the early part of November was so unfavorable that the last section of grillage in the wing of east crib was not laid until the 14th of November. It was then put in place and loaded with stone. On the night of the 14th a great easterly storm visited the Atlantic coast. The wind blew very strong from the east-southeast, continuing until 6 o'clock on the morning of the 15th. By this time there was a very heavy sea running; this, with the extraordinary high tide, (which was 4.2 feet above mean high water,) moved the section of grillage put in on the 14th; the stone with which it was loaded was washed off, and it then broke loose and came ashore. Some 50 feet of the wing which was nearly completed, but not fully loaded, was moved out of line; this, however, was soon put in place, the grillage relaid, and the whole wing completed before the close of November.

During the season of 1871 we hauled from the shore and interior of the island, for

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filling and backing to the crib, and for foundation of wings, about 5,600 tons of stone. That portion of the east crib completed prior to the 15th of November was put to as severe a test by the storm of that date as it is likely it will ever be subjected to, and, as it was not injured, we think it will stand until the timber becomes decayed.

Before that time, the filling in of sand, which is now going on on the east side, in the angle formed by the crib and shore, will have formed a new beach in front of it, which will render the rebuilding of it unnecessary.

Work on the west crib was commenced on the 24th April, 1872, and the whole crib and wing finished by the 1st of this month.

During the past winter it was found that in storms from the south and southeast the waves strike the head of the main work, and by it the direction is so changed that when they reach the shore they are moving from the westward toward the work. By this motion of the waves sand is brought and deposited inside the breakwater in the angle formed by the breakwater and the shore. To arrest this motion of the waves from the westward along the shore a jettee has been commenced. This jettee starts from a point on the shore about 1,200 feet to the westward of the main work, and, if continued, would join the main breakwater at a point about 1,100 feet from the shore where a sufficient opening should be left. It is built of such stone as are found on the shore and in the interior of the island, has a triangular cross-section, and is to be built up to a little above extreme high-water. At this date about 270 feet of this jettee has been completed.

The work of dredging out our temporary harbor was commenced on the 16th of August by employing a dredge by the day. The contractor for furnishing granite for the main work, under the appropriation made by act approved June 10, 1872, commenced to deliver stone August 25.

It is designed this season to complete the dredging of the inner harbor, to remove the scattering rocks about the entrance to the same, to build a wharf on the east side crib, and to put in the necessary "fender-piles" at the opening to inner harbor, so that a harbor will be available for small boats used by the islanders, and such vessels as may be employed by the contractor in putting stone into the main work during the storms of the coming fall and winter. The bowlders obstructing the anchorage-ground behind the main breakwater will also be removed.

The value of the temporary harbor was well tried in the severe storm of November 14 and 15, 1871. We then had only the crib of the easterly part completed, but two scows used on the work and moored on the west side of the crib were uninjured, as were the boats of the islanders moored at the "stakes" west of the crib.

Before the building of the crib the islanders hauled out all of their small boats at the approach of a storm, and prior to the putting in of the substructure of the main work the largest boats used at the island were not safe unless hauled up on the shore.

During another heavy easterly storm in November the mail boat, with a number of passengers, arrived at the island, when the water was too low for her to be brought into the landing; she came to anchor under the lee of the breakwater, and her passengers were landed in a row-boat.

If the breakwater had not been built this boat would have been compelled to lie to until the tide had risen sufficient to let her in to the landing, to the great danger of all on board.

The inner harbor has been used since its completion by small yachts, and during the easterly storm of August 30th the schooner Ruth Halsey, Captain Mitchell, lay in this harbor, as did the sloop Jennie, Captain Card.

During the season of 1871, and up to July of this season, I was assisted on this work by W.W. Starr, jr., civil engineer, and since then by P. M. Blake, civil engineer.

Respectfully submitted.

J. P. COTTON.

Brevet Major-General G. K. WARREN,
U. S. A., Newport, Rhode Island.

T 4.

IMPROVEMENT OF PAWCATUCK RIVER, RHODE ISLAND AND CONNECTICUT.

As stated in my last annual report a contract was made with Mr. Emory R. Seward, of Albany, New York, to do the dredging under the appropriation of $10,000, approved March 3, 1871, at the rate of 35 cents per cubic yard, by which he agreed to complete the work by the 31st of October. He, however, failed to commence the work by that time. Under the terms of the contract as soon as I could engage other

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dredges I set them at work, intending to charge Mr. Seward with the difference in cost if there should be any.

The dredge owned by Mr. T. J. Hill, of Providence, worked at the rate agreed by Mr. Seward, so there was no charge to make on this account. It was found that a large portion of the channel-way was so shoal that scows could not be used alongside the dredge until one cut had been made, throwing the material upon one side, and as this could not be done by the yard, one of Morris F. Brainard's dredges was employed by the day for this purpose, being paid the same price as for similar work in the Peconic River, where he had been employed by the day as the lowest bidder, after advertisement had been duly made. On this arrangement, which was the best that could be made, there was no sure ground for a charge for increased cost against Mr. Seward, and I allowed the matter to rest. There was also an error in the map of the first survey made under my direction, in locating "certain draught" point too low down the river, which caused me to direct a cut to be made as first planned, when it was not immediately required.

About $5,500 was expended in the autumn of 1871, and the balance of the appropriation last spring, in dredging and superintendence, and in resurveying.

The following is a statement of the work done:

8,206 cubic yards dredged, at 35 cents per cubic yard	$2,872 10
4,724 cubic yards dredged, at 28 cents per cubic yard	1,322 72
401¼ hours' work of dredge, at $8.75 per hour	3,510 94
Resurvey and superintendence	2,294 24
Total	10,000 00

From the experience now had the revised estimate of the cost of making a channel up to Westerly, 60 feet wide and 5½ feet deep at mean low water, is presented, and in round numbers, in addition to what has been done, is $20,500, for the details of which and of the work done I refer to the annexed report and map by Mr. Henry S. Van Ingen, civil engineer.

The amount appropriated June 10, 1872, for continuing the work is $10,000, leaving $10,500 as necessary to make the narrow channel above estimated for. As this is only the least that will do, and not all that is desirable, I recommend an additional appropriation of $15,000 for the fiscal year ending June 30, 1874.

Advertisements were made June 28th for proposals to do the dredging under the last appropriation, according to the following specifications:

This appropriation will be used to make a channel 50 feet wide and 5 feet deep at mean low water, from opposite the cemetery up river toward Westerly.

The material to be dredged consists of sand and some gravel. It can be deposited with scows of 4½ feet draught, at all times, within a distance of two and a half miles, and at high water within one mile.

The rise and fall of the tide is about 2½ feet. The depth on the bars to be dredged is from 1½ to 4 feet at mean low water.

Proposals will state price per cubic yard, measured in the scows, for dredging and dumping the material. Care must be taken not to confound *Pawtucket River* with this one.

The lowest proposal was made by Mr. E. M. Payn, of Albany, New York, at 36½ cents per cubic yard, and the contract has been made with him.

The only other proposal received was from Mr. Morris F. Brainard, which was 53 cents per cubic yard.

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The Pawcatuck River is the boundary between the collection-districts of Stonington and Providence. Stonington is the nearest port of entry. The amount of revenue collected during the fiscal year ending June 30, 1872, at Stonington was $33,500, and at Providence $301,738.14.

Westerly is a place of growing importance, requiring much coal for its manufactories, which now reaches the place with difficulty. The fine granite quarries in this vicinity would be more readily developed by deepening the channel of the river, so as to furnish a readier market for the coarser products of the quarries.

Statement of funds.

Amount available July 1, 1871	$9,[illegible]
Amount appropriated by act of June 10, 1872	10,[illegible]
Amount expended during the fiscal year ending June 30, 1872	9,651 [illegible]
Amount available July 1, 1872	10,[illegible]
Amount required for the fiscal year ending June 30, 1874	10,[illegible]

ENGINEER OFFICE, UNITED STATES ARMY.
Newport, Rhode Island, July 1, 187[illegible].

GENERAL: I have the honor to submit the following final report, with map, of operations for the "improvement of Pawcatuck River, Rhode Island and Connecticut:"

In accordance with your instructions of November 2, 1871, from this office, I repaired to Westerly, Rhode Island, to take charge of the improvements then in progress in the Pawcatuck River. Work had been commenced October 23, under the charge of General H. A. Frink, civil engineer. A cut 875 feet long, 25 feet wide, and 5½ feet deep at mean low water, had been made off "Gravelly Beach" by Mr. Brainard's dredge, the material being thrown over the side, and she had just moved up the river and commenced a cut through "Kenyon's Bar." An additional survey had also been made by Mr. John H. Dager, civil engineer.

From that time work was continued until November 30, when the ice compelled the suspension of operations until the spring. A channel was begun through the shoal above "the Rocks," by Mr. Hill's dredge, the material being scoured away, and Mr. Brainard's dredge completed one cut, 1,600 feet long, 25 feet wide, and 5½ deep at mean low water, through "Kenyon's Bar," throwing over the side. Mr. Hill received 35 cents per cubic yard for all material removed, while Mr. Brainard received $8.75 per hour.

Operations were resumed March 25, 1872, by Mr. Hill's dredge, and continued until April 18. The channel, through the shoal above "the Rocks," begun last fall, was completed. It is 935 feet long, 70 feet wide, and 5½ deep at mean low water. On the completion of this work Mr. Hill withdrew his dredge, on account of the impossibility of her working profitably in the shoaler and harder material above, and on account of prior engagements. Arrangements were then made with Mr. Morris F. Brainard, of Albany, New York, to dredge through the shoals, from opposite the cemetery, upward, on the following terms: He to dredge a single cut, throwing over the side, at $8.75 per hour; then to make a second cut, at the same time removing the material thrown out from the first cut, and scow it all away, at 28 cents per cubic yard; the shallowness of this portion of the river rendered this method necessary. A channel was thus made 945 feet long, 43 feet wide, and 5½ deep at mean low water. Work was suspended May 21, on account of the appropriation being expended, and I returned to this place the following day.

The material dredged in this river, below "the Rocks," was mud; above this it was sand, intermixed in certain places with gravel, and occasional bowlders. It was dumped partly in "Colonel Willie's Cove," at the mouth of the river, and partly in Babcock's South Cove.

The following is a summary of the work done and expenditure therefor:

8,206 cubic yards, at 35 cents per cubic yard	$2,[illegible]
4,724 cubic yards, at 28 cents per cubic yard	1,[illegible]
401½ hours, at $8.75 per hour	3,[illegible]
Total for dredging	7,[illegible]
For additional survey, engineering expenses, &c	2,[illegible]
Balance on hand July 1	[illegible]
	10,[illegible]

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The future improvement of the Pawcatuck River, so as to give 5½ feet of water at low water up to Westerly, requires almost continuous dredging from the point reached this last spring up to the wharves, and the widening of the channel dredged opposite the cemetery. This was not made the full width, as it was deemed desirable to make a channel as soon as possible through the shoal and connect the upper cut with the lower. In addition to this, there is some dredging needed at points indicated on the accompanying map, which is desirable, but not absolutely essential to the end sought. There are, also, a few rocks to be removed at different points in the river, the expense of which would be small. The material to be dredged is sand and gravel, intermixed with small stones in the upper part of the river.

The following is an estimate of the cost of the improvements proposed, essential and desirable:

To secure a channel 60 feet wide, 5½ deep, to Westerly:

36,964 cubic yards, at 45 cents per cubic yard	$16,633 80
10 per cent. for engineering expenses, contingencies, &c.	1,663 38
	18,297 18

Dredging off "Gravelly Beach," so as to straighten the channel at that point, by making two cuts alongside that made last fall:

5,833 cubic yards, at 25 cents per cubic yard	$1,458 00
Removal of a point opposite "Babcock's Cove," marked A on map, 500 cubic yards, at 25 cents per cubic yard	125 00
Removal of a point, an old oyster-bed, opposite Lottery, (marked B on map,) 500 cubic yards, at 30 cents per cubic yard	150 00
Removal of rocks	250 00
	1,983 00
10 per cent. for engineering expenses, contingencies, &c	198 30
	2,181 30
Estimated cost of all improvements	$20,478 48

Very respectfully,

HENRY S. VAN INGEN,
Civil Engineer.

Brevet Brigadier-General E. K. WARREN,
Corps of Engineers, U. S. A., Newport, Rhode Island.

T 5.

IMPROVEMENT OF THAMES RIVER, CONNECTICUT.

At the date of my last annual report, August 31, 1871, nothing had been done on this river under the appropriation of $15,000 approved March 3, 1871, except to make a contract with Mr. Emory R. Seward, of Albany, New York, for dredging, at 20 cents per cubic yard. He did not get ready to work till the 1st of December, and then was prevented from doing anything by the ice. He commenced work on the 12th of April, 1872, and by the 31st of August had removed 45,954 cubic yards of material from the bars known as "The Hay-cocks" and "Bushnell's Reef," making at these places the channel 11 feet deep and 100 feet wide, at mean low water. This appropriation will complete the channel of the same capacity up to the rolling-mill wharf. The time of Seward's contract was extended so as to allow him to work out the appropriation.

The act approved June 10, 1872, appropriated $10,000 for continuing the improvement through the fiscal year ending June 30, 1873. Adver-

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tisements for proposals were issued June 28, 1872, to do the work according to the following specifications:

Dredging is to be done in the channel of the river below Norwich, Connecticut, where it is less than 100 feet wide and 11 feet deep at mean low water. The depth of water on the bars is now about 9 feet at mean low water. The material to be dredged is sand, with some mud.

The dredged material can be deposited at all times within a distance of one and a half miles, and at high water in coves near where the dredging is done with scows of 6-feet draught.

Proposals will state the price per cubic yard, measured in the scows, for dredging and dumping.

The lowest proposal was Mr. E. R. Seward's, to dredge for 19 cents per cubic yard; and a contract has been made with him.

The following is an abstract of the proposals received:

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Abstract of proposals for the improvement of the Thames River, Connecticut, received at the Engineer Office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Price per cubic yard for dredging.	Commence—	Complete—	The amount appropriated, at the price named, would remove—	Remarks.
Emory R. Seward, Albany, N. Y	19 cents	Sept. 1, 1872	June 30, 1873	52,631 cubic yards	
Sidney F. Shelbourne, 11 Gold street, New York City	19½ cents	(*)	June 30, 1873	51,948 cubic yards	No certificate that guarantors are responsible parties.
Morris F. Brainard, Albany, N. Y	21 cents	Aug. 20, 1872	Dec. 30, 1872	47,619 cubic yards	
Francis H. Smith, 121 Front street, New York City	22 94-100 cents	Aug. 15, 1872	June 30, 1873	43,592 cubic yards	
Edgar M. Payn, Albany, N. Y	23 cents	Aug. 5, 1872	June 30, 1873	43,477 cubic yards	Signatures of guarantors are not witnessed.
S. F. Shortland & Bros., 106 Wall street, New York City	24 73-100 cents	Aug. 15, 1872	(†)	40,436 cubic yards	No certificate that the guarantors are responsible parties.
Elijah A. Bill, Norwich, Conn	28 cents	Aug. 10, 1872	June 30, 1873	35,713 cubic yards	Received at office at 11 a. m. July 30, 1872.

* Five days after award of contract.

† As soon as practicable.

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It has been stated in former reports that the Middle Ground, by being washed away, furnished the material by which the cuts in the channel below become filled up. The experience we have had does not sustain this opinion, because the Middle Ground remains all the time unchanged, and the dredged channels are continually filling up. Observations the past season show that this material is brought down by the streams which form the Thames River, and deposited in it, and it seems probable there is no remedy for this but continued dredging. It is expected that the funds in hand will do much toward removing the Middle Ground, a thing the people of Norwich greatly desire, and its removal may serve to form a catch-basin or receptacle to prevent the material from above passing below this place.

I alluded in my last annual report to a statement that had been made about the effect of the wing-dams, many years built upon the Thames, having had the effect to reduce the height of the flood tide at Norwich, on an average over one foot. Careful examination of the records of tides before the jettees were built, and since, shows that they have not sensibly affected the rise of the tide, and that the idea probably arose from comparing the former extreme tide with the present mean tide.

This is an interesting engineering question, and merits consideration on that account, and I give the following exact comparison of the tides before and after the wing-dams were built.

By observations under Major Bache, Topographical Engineers, United States Army, between July 14 and 30, 1829. (See his map on file in the Engineer Department:)

The mean rise and fall is	3.19 feet.
Fall of lowest tide below mean low water	.925 "
Rise of highest tide above mean low water	3.75 "
Extreme rise and fall	4.675 "

By observations under Colonel Houston, United States Engineers, in 1866:

The mean rise and fall is	3.125 feet.
Fall of lowest tide below mean low-water	.854 "
Rise of highest tide above mean low-water	3.771 "
Extreme rise and fall	4.625 "

I have not thought it necessary to ask for any appropriation for the fiscal year ending June 30, 1874.

Thames River is in the New London collection-district. New London is the port of entry, and the revenue collected there during the fiscal year ending June 30, 1872, was $72,601.14.

Statement of funds.

Amount available July 1, 1871	$15,335 [illegible]
Amount appropriated by act of June 10, 1872	10,000 [illegible]
Amount expended during the fiscal year ending June 30, 1872	7,225 [illegible]
Amount available July 1, 1872	18,10[illegible]

T 6.

IMPROVEMENT OF CONNECTICUT RIVER BELOW HARTFORD, CONNECTICUT.

My report, submitted February 12, 1872, accompanied by one from General Theo. G. Ellis, civil engineer, both printed as House Ex. Doc.

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No. 251, second session Forty-second Congress, gave a complete account of this work up to that date. Since then, some dredging has been done at Pistol Point Bar, and a survey begun at Saybrook Bar, at the mouth of the river, under the appropriation of $35,000, approved March 3, 1871; and without exactly repeating the report of February 12, I will here make extracts from it, combining General Ellis's report with mine and adding such information as will bring the whole down to the close of the fiscal year ending June 30, 1872.

By reference to my last annual report, it will be seen that the contract for removing Chester Rock was awarded to Mr. W. D. Daisley, of Boston, at $20 per cubic yard, the lowest proposal received. After a short trial he gave up the work and declined to enter into a contract. As he had not proper preparations for the work, and appeared to have begun in good faith, but without comprehending the difficulties before him, I did not think it worth while to attempt to compel him to do the work. I have since been led to think the removal of this rock as not of immediate importance, and have taken no further measures to have it removed.

My last annual report also shows that the contract for dredging, under the appropriation approved March 3, 1871, was awarded to Mr. Morris F. Brainard, of Albany, New York, who made the lowest proposals.

There are six maps on tracing cloth, showing the localities, with the parts worked upon shown in colors by months, and with figures indicating quantities. (These maps are all the same as those forwarded with my report of February 12, 1872, above referred to, except that for Pistol Point Bar, where some dredging has since been done, and another map of this bar, showing this subsequent work, is sent herewith.)

At Hartford Bar, the dredging for widening the channel continued from July 1st to November 5th, when the proposed channel of 200 feet wide and 8 feet below extreme low water, or 9½ feet below ordinary low water, was finished. For the greater part of the distance the actual width taken out is 210 feet. The dredging-machine used was a large one, with side-scoops on endless chains, 25 feet apart, so that the dredge moved laterally 25 feet to cut a complete channel 50 feet wide. A part of the work was done early in the season by a smaller Osgood dredge, cutting about 30 feet wide, and taking two cuts, which made an even number of cuts with the large machine run over the 200 feet. This is shown on the accompanying tracing. The amount of work done in each month, at this place, is as follows:

	Cubic yards.
July, earth excavated	10,597
August, earth excavated	12,783
September, earth excavated	13,309
October, earth excavated	11,702
November, earth excavated	1,532
Total	40,923

The work of dredging the channel at Clay Banks was done from July 26 to August 3. It is for a short distance, and about 100 feet wide. The depth is 8 feet at the lowest water. To make the channel at this point much wider is unnecessary, as for some distance below it is quite narrow. A great amount of dredging would be required, with perhaps no benefit to navigation, as it would diminish the depth of water. The small stone-heap, marked H on the map, was removed by the steamboat company previous to the Government work being commenced. The quantities removed at this place, are as follows:

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	Cubic yards.
July, earth excavated	2,173
August, earth excavated	1,230
Total	3,403

At the old pier, marked I on the map, dredging was commenced August 8, but the dredge being sent to Chester Rock, it was discontinued until the 21st, when it was resumed and finished on September 1. This dredging was to remove the obstruction caused by the old stone pier.

The quantities removed at this place are as follows:

Months.	Earth.	Loose rock.
	Cubic yards.	*Cubic yards.*
August	1,469	1,5[illegible]
September	192	121
Total	1,661	1,701

The work at pier J was commenced September 2, and completed on the 7th. Like the preceding, this was to remove the obstruction caused by the old stone pier. The quantity taken out at this point is as follows: September, earth, 1,668 cubic yards; loose rock, 650 cubic yards.

At Pratt's Ferry Bar, dredging was done to widen the channel already made, from July 11 to 25, and from August 3 to the 7th, as shown on the maps. The quantities taken out at this place are as follows:

	Cubic yards.
July, earth excavated	4,8[illegible]
August, earth excavated	1,1[illegible]
Total	5,9[illegible]

At the piers and bar at South Glastonbury, dredging was commenced on September 8, and completed November 23. This dredging was to straighten the channel, and remove the cause of the obstruction, by taking out part of the large stone piers, as shown on the accompanying map. The quantities taken out at this place are as follows:

Months.	Earth.	Loose rock.
	Cubic yards.	*Cubic yards.*
September	10,176	491
October	13,986	24
November	8,736	27
Total	32,898	542

Work was commenced at Pistol Point Bar on the 24th of November, and was stopped by ice on the 29th. The quantity taken out at this place in November, 1871, was 2,154 cubic yards of earth. Work was resumed on this bar on the 24th of April, 1872, and 314 cubic yards excavated during the month. In May the amount excavated was 12,0[illegible]

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cubic yards. In June it was 10,499 cubic yards. This closed this contract with Mr. Brainard.

Months.	Earth.
	Cubic yards.
November, 1871	2,154
April, 1872	314
May, 1872	12,038
June, 1872	10,499
Total	25,005

All of the foregoing dredging has been taken out 8 feet below the lowest water, or 9½ feet below the ordinary low level of the river in the dryest time in the summer months.

At Chester Rock a deep trench was dredged out around the part of the rock to be removed, to facilitate the operations of the contractor. This was done between August 9 and 16th. The contractor, however, did little toward removing the rock. He removed such loose portions as he could without blasting, and afterward drilled four small holes, which he blasted on the 29th and 30th of August. They displaced, however, very little of the solid rock. The contractor did very little afterward, and on the 18th of September packed up and left with his schooner and tools. The quantities taken out at this place are as follows:

Months.	Earth.	Solid rock.
	Cubic yards.	*Cubic yards.*
August	1,703	16.4
September		8.8
Total	1,703	25.2

I have been particular in giving the amount of dredging at each place in this report for convenience of future reference, for the time is coming when it will probably be desirable to compare the cost of this method of improvement with some other.

For this purpose, too, careful surveys have been made, and permanent stone reference points were set at Hartford Bar, Pratt's Ferry, Glastonbury Piers, and Pistol Point Bar. The stones are 3½ feet long, squared to 4 inches at the top, with a hole drilled in the center, filled with wooden plugs, having a copper nail to indicate the exact point. The position of these stones and their heights above low water are shown on the maps of the places before mentioned.

During the time from July 1 to December 1 the height of the river at the Hartford gauge has been taken three times daily, at about the hours of 8 a. m., 12 m., and 5½ p. m.

The Connecticut River below Hartford affords now a channel-way at low water of 8 feet depth, but will probably require an annual expenditure for dredging to maintain this capacity, for the banks are subject to abrasion in many places, and channels already made are liable to slit up.

Some of the dredging done at Pistol Point Bar is over a part of the river previously dredged in 1870.

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The contract made in 1870 with Mr. Emory R. Seward, to do the piling required at Hartford Bar, was not fulfilled by him, and was so stated in the last annual report. He, however, agreed to go on with it in 1871, if the time were extended; and this extension was granted to him. He has since performed the work.

The number of piles driven in different months is as follows:

August	180
September	187
October	180
Total	547

In the month of January, during a rise in the river, there was a tendency to cut out between the shore-end of this piling and the bank, and about 23 feet of sheet-piling was put in to prevent it. The work has stood well, and fully answers its purpose of protecting the banks from abrasion.

Appropriation of $40,000, *approved June* 10, 1872.

Advertisements for proposals for further dredging were issued June 28, according to the following specifications:

(1.) DREDGING AT "PRATT'S FERRY BAR."

The amount to be removed here is about 10,000 cubic yards of sand and mud. The excavation to be done is from 6 to 9½ feet below ordinary low water. The tide rises about 1 foot.

(2.) DREDGING AT PISTOL POINT BAR.

The amount to be removed here is about 10,000 cubic yards of sand and mud. The depth of water is from 6 to 9½ feet. The tide rises about 2 feet.

REMOVAL OF THE WRECK OF SCHOONER "BAY STATE" FROM SAYBROOK BAR.

This wreck lies about one-half a mile south of the Saybrook light, on the easterly edge of the channel, with about 6 feet of water around her at low water. The hull is 65 feet long and 22 feet wide, and is so much broken up that it will probably have to be raised in pieces. The wreck is nearly covered at high water. The tide rises here about 4 feet. The portions of wreck removed are to be deposited where they will not again obstruct navigation.

Proposals for wing-dams and other improvements above Hartford will not be solicited until further examinations have been made.

The following is an abstract of the proposals received:

Abstract of proposals for the improvement of the Connecticut River below Hartford, received at the engineer office, U. S. A., Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Price per cubic yard for dredging.		Removal of the wreck of schooner Bay State, at mouth of river.	Commence—	Complete—	Amount available after removal of wreck at mouth will remove—
	Pratt's Ferry.	Pistol Point.				
						Cub. yards.
George W. Townsend, 17 Court street, Boston, Massachusetts.	.....	.....	$800 00	Sept. 1, 1872	June 30, 1873	.....
Francis H. Smith, 121 Front street, New York City.	.....	.....	1,744 00	.....	.....	.....
Morris F. Brainard, Albany, New York.	25 cents	25 cents	.....	Oct. 1, 1872	June 30, 1873	156,000
Henry C. Douglas & Co., Hartford, Connecticut.*	25 cents	25 cents	.....	Sept. 1, 1872	July 1, 1873	156,000

* Received at office 11 a. m., July 30, 1872. Proposals not in duplicate. Signatures of guarantors not witnessed.

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The contract for dredging was awarded to Mr. M. F. Brainard, but the river has been at too high a stage to permit of any work being done, and none has been needed.

The contract for removing the wreck was awarded to Mr. G. W. Townsend, and he is expected to do it in September.

The Saybrook Bar, at the mouth of the river, has been carefully surveyed by General Ellis, civil engineer, but the plan of improvement cannot be fixed upon till the completion of the maps, which are now in progress.

The cheapest improvement of the Saybrook Bar, so as to deepen the entrance, can probably be best made by some kind of a vessel to plow up the material and allow the currents to sweep it away; and for this purpose, and for dredging at other places, I recommend an appropriation of $40,000 for the fiscal year ending June 30, 1874.

The Connecticut River below Hartford is in the Middletown collection-district. Middletown is the nearest port of entry. The revenue collected there during the fiscal year ending June 30, 1872, was $4,695.72.

Statement of funds.

Amount available July 1, 1871	$52,829 28
Amount appropriated by act of June 10, 1872	40,000 00
Amount expended during fiscal year ending June 30, 1872	52,583 15
Amount available July 1, 1872	40,246 13
Amount required during fiscal year ending June 30, 1874	40,000 00

T 7.

IMPROVEMENT OF CONNECTICUT RIVER ABOVE HARTFORD, CONNECTICUT, AND BELOW HOLYOKE, MASSACHUSETTS.

The condition of this work at the close of last year was shown in my report dated January 18, 1872, printed as House Executive Document No. 142, Forty-second Congress, second session, which, with that of General Theodore G. Ellis, civil engineer, my assistant, I append to this. Nothing has been done since, except to prepare for additional surveys.

In this former report it is stated that the first $20,000 for this work had been devoted to making wing-dams of stone between Hartford and Windsor Locks, for the purpose of increasing the low-water depths at the Scantic River Bar, Strong's Island Bar, and Farmington River Bar, at the latter of which the work was interrupted by a rise in the river. It was designed to build wing-dams also at Barber's Landing and at Higby's Point. At the time this work was suspended, there remained an unexpended balance of the first appropriation amounting to about $5,000. The continued high water has thus far prevented a resumption of the work, or even an examination to ascertain the condition and effect of what has been done. By the act approved March 3, 1871, $20,000 more was appropriated to improve the river above Hartford and below Holyoke. About $5,500 of this was used in making a thorough survey and plan of improvement of the Enfield Rapids, the result in full being in the report made January 18, 1872, above referred to, and now appended to this report.

This report shows that $870,000 will be required for the improvement of the Enfield Rapids alone, which can only be by a canal, and that so great a sum will probably be required to thoroughly improve the river

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between these rapids and Hartford; that the extension of the canal down to Hartford may be a better plan. The determination of this question called for additional surveys.

Further surveys are also required between the Enfield Rapids and Holyoke. In this report of January 18, 1872, the attention of Congress was called to the fact therein established, that a thorough improvement of the river over the entire space designated would cost in the neighborhood of $3,000,000, and that only ameliorations of such insignificant navigation as now existed could be produced by small appropriations.

By the act approved June 10, $20,000 were appropriated for improving the river between the Enfield Rapids and Holyoke. From such preliminary examinations as I had made no special improvement in this section of the river had been reported necessary, so that I have directed a careful survey to be made of it, to see whether the money can be used to advantage. This survey, and that between the Enfield Rapids and Hartford, will be made this season, if the river gets sufficiently low. It is well to state here that the former survey between the Enfield Rapids and Hartford was made in the depths of midwinter, and for the purpose of attempting to ameliorate the navigation with the limited means. The next survey will be made with a view of thoroughly ascertaining the capacities of the river for the improvement, and to determine upon the best plan for doing it.

For further information in regard to the subject I beg leave to refer to the annexed reports.

Statement of funds.

Amount available July 1, 1871	$19,392 57
Amount appropriated by act of June 10, 1872	20,000 00
Amount expended during the fiscal year ending June 30, 1872	1,541 43
Amount available July 1, 1872	37,851 14

ENGINEER OFFICE, UNITED STATES ARMY.
Newport, Rhode Island, January 18, 1872.

GENERAL: I have the honor to make the following report of operations for the improvement of the Connecticut River above Hartford, Connecticut, and below Holyoke, Massachusetts, during the last half of the year 1871.

The condition of this work at the date of my last annual report, August 31, 1871, is given in your printed last annual report, pp. 756 to 768 inclusive. From this it appears that the first $20,000 appropriated, approved July 11, 1870, for the river above Hartford, had been devoted to surveying and improving the river by wing-dams between Hartford and Windsor Locks, and that the work was then in progress on Scantic Bar. (See p. 760.)

The appropriation of $20,000, approved March 3, 1871, was made specifically to embrace the Enfield Falls, and yet so small an amount would seem to indicate that with regard to an obstruction of such magnitude, nothing beyond a thorough survey and examination of the river could have been contemplated, although it was too large an amount for an ordinary survey.

Had, however, the appropriation been large enough to justify an attempt to improve the navigation at the Enfield Falls, it would nevertheless in this case have been necessary to make a survey and elaborate a plan. A survey being thus a first requisite, I directed one to be made by the assistant in charge of the Connecticut River improvements. This assistant is General Theodore G. Ellis, civil engineer, a resident of Hartford, Connecticut.

The survey was in progress at the time of my last annual report, (see p. 763.)

During the first part of October I made a personal examination, in company with General Ellis, of the falls and the existing canal around them on the west shore of the river. As it was important in engineering for such an expensive work to take cognizance of the capabilities of the river for navigation above and below, we extended our examination up to and including the water-power dam at Miller's Falls, about

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thirty-two miles above Holyoke. After a thorough personal discussion with General Ellis on the main points to be considered, I left it with him to prepare the report, and I transmit it herewith.

It is more especially devoted to the improvement of the Enfield Falls or Rapids, but takes into the discussion of its value and importance the capacity for navigation of the river above and below it. With regard to the special part, the falls, the subject is very completely and clearly presented, and, though so concise as to be soon read through, it is exhaustive.

The Enfield Falls are entirely in the State of Connecticut.

It would be perhaps sufficient for me to stop here with my report; but in order to aid those who are willing to adopt the conclusions, and have not time to thoroughly consider the matter themselves, I will endeavor to give some of the leading features and conclusions arrived at, with certain military matters of incidental importance.

Hartford, on the Connecticut River, is about forty-nine miles by the course of the channel from the sound, and, since the improvements of the last two years, can be reached by vessels of from 7½ to 8 feet draught at low tide. The tide in low stages is sensible here, and amounts to about one foot.

From Hartford to the foot of the Enfield Falls, the distance is ten and three-fourths miles, and by an examination in low water of 1870 there was in some places a depth over the bars of only about 15 inches. The bed, however, was sandy and very broad, and the volume of the water flowing was about 4,000 cubic feet a second on a gentle slope. Within this space the tide becomes insensible. After I have finished with the plan of improving the Enfield Falls, I shall recur to the question of improving this reach of river.

The Enfield Falls extend up the river five and one-fourth miles, the head of them being sixteen miles above Hartford. The bed of the river is here continuous rock, and the total fall at low water is 31.8 feet. The fall is not uniform, but arranged in slopes as follows: Beginning at the head, in first 4,800 feet, falls 10.1 feet; in next 7,600 feet, falls 1.7 feet; in next 8,800 feet, falls 17.8 feet; in next 6,500 feet, falls 2.2 feet. The slope becomes more uniform as the river rises. At the highest flood the total fall is 17.6 feet. The rise from lowest to highest water at the head of the falls is about 20 feet; at the foot of the falls, 30 feet. The volume at high water is about 162,000 cubic feet per second. General Ellis gives these quantities in more detail, but enough is here stated to show any engineer that navigation around such an obstruction can only be obtained at considerable expense.

There is practically no natural navigation at these falls, and it is enough here to say that the improvement of the natural channel so as to procure the navigation desired is impossible.

The existing canal is limited by the capacity of its locks to passing boats 77 feet long, 18 feet wide, although as a canal it is a respectable work.

From the Enfield Falls to Holyoke, a distance of eighteen miles, there is now at ordinary low water a depth of navigation said to be from four to five feet. Some improvement will, however, undoubtedly be required to realize this, and draws will have to be made in the bridges. Holyoke is thirty-four miles above Hartford. At Holyoke a dam has been constructed across the river, and canals for the water-power constructed on the west side of the river, which can at no very great expense be altered and adapted to the passage of boats, and it would probably become profitable to do so as soon as vessels could reach there from below. At Holyoke the lockage would have to raise vessels a height of sixty feet.

From Holyoke to the foot of Miller's Falls, a distance of sixty-six miles above Hartford, the river contains no serious obstructions, flows over a sandy bed, and is susceptible of ordinary river improvements, but I do not know its present capabilities. If navigation should ever be made continuous to this point, it would then be in connection with the low-grade railroad passing through the Hoosac Tunnel, now in a fair way of early completion. It does not, however, seem even remotely probable that it will pay to construct a canal around Miller's Falls; and thus we are limited in our consideration of the value of the improvement of the Enfield Falls, first, to the thirty-four miles of river between Hartford and Holyoke, and, proximately, to the additional thirty-two miles between Holyoke and Miller's Falls.

I will now proceed to the consideration of the improvements at the Enfield Falls.

General Ellis considers estimates for and discusses the advantages and disadvantages of five different plans. In general terms, he states them as follows:

First plan.—A canal on the *west* side of the river, extending from the present dam at the head of the rapids, parallel to the old canal, down to a point just above the village of Windsor Locks; and a channel to the deep water below, to be formed by excavating in the bed of the river. Cost, $1,293,868.

Second plan.—A canal on the *east* side of the river from the dam, at the head of the rapids, to the deep water below the rapids. Cost, $869,636.

Third plan.—To dam the river at the head of King's Island, or a little below, and

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continue downward with a canal on the *east* side of the river to the deep water below Cost, $961,609.

Fourth plan.—To dam the river at a point near the Enfield bridge, and lock into the river below; dam it again just below the railroad-bridge near Windsor Locks and continue with a canal to the foot of the rapids. Cost, $1,222,308.

Fifth plan.—To improve the old canal so as to be navigable for boats of increased size. Cost, $1,907,565.

The discussion of these plans justifies General Ellis in rejecting the first, fourth, and fifth plans above stated, leaving him only to choose between the second and third, and a modification of the fifth, by which the old canal would be but partially improved at the present time.

After fully considering the arguments he presents, I am in favor of adopting the second plan proposed by him, provided no unexpected obstacles should be met in securing a right of way. I therefore adopt, as the estimate for improving the Enfield Falls, $869,636, or, in round numbers, $870,000.

The least width of the canal is to be 150 feet on the water-line, and it will have three lift-locks to overcome the fall of 31.8 feet, whose dimensions are to be 200 feet in length, 50 feet in width, and to have six feet of water on the lower miter-sills.

An estimate of these proportions requires a brief statement of the causes which have led to its being made and brought to the attention of the Government.

In the appropriation act approved July 11, 1870, there was an appropriation of $40,000 for improving the Connecticut River, which was made after an estimate had been submitted for improving this river below Hartford, made in accordance with section 4 of the act for improvement of rivers and harbors, approved March 2, 1867. In this section of this last-named act the present question took its origin.

The appropriation of $40,000, in 1870, was coupled with an understanding among members of Congress that $20,000 should be expended above Hartford, in which portion of the river no surveys or estimates had been directed by Congress, or made by any department of the Government. After considerable delay in 1870, in ascertaining whether this understanding by members of Congress meant that the $20,000 should be spent in Massachusetts, (thus skipping over the Enfield Falls and the shoals between them and Hartford,) or not, the conclusion was arrived at about the middle of December, 1870, that this fund might be expended satisfactorily to all parties by beginning at Hartford and working upward. This was evidently the only sensible conclusion.

During the winter an examination of the river throughout the State of Massachusetts and the survey of the ten and one-fourth miles between Hartford and the foot of the Enfield Falls, were made as well as could be at that season, and a plan submitted for spending the $20,000 in wing-dams between Hartford and the falls, (see pp. 756 to 760, inclusive, of your printed annual report for 1871.)

The plan thus submitted did not comprehend a thorough improvement of the river, but simply such ameliorations of the existing navigation as the amount of the appropriation seemed to contemplate, and thus facilitate the passage of such boats as were now running, and suited to the capacity of the existing canal around the Enfield Falls.

This work has been prosecuted during the past season at the Scantic River Bar, Strong's Island Bar, and Farmington River Bar, where wing-dams have been built. The work was interrupted before completion by a rise in the river, and about $5,000 of the appropriation applicable to this work remains unexpended.

We shall have to wait till after the subsidence of the next spring freshets before we can fully determine the effect which this work has produced.

By the act for improving rivers and harbors approved March 3, 1871, Congress appropriated $20,000 for improving the Connecticut River above Hartford and below Holyoke, thus specifically, by law, including the Enfield Falls, as stated in the beginning of this report. This law, however, would have allowed us to go on and expend this additional money between Hartford and the foot of the falls, as certain citizens of Windsor Locks claim that it was intended we should; but there was an equally urgent request from citizens of Springfield, Massachusetts, claiming that there was no use in improving the river below the falls while the latter remained in their present condition.

To those acquainted with the magnitude of the improvement required, it seemed impossible that Congress should have ever contemplated beginning the improvement of the Connecticut River above Hartford and below Holyoke with $20,000. But as Congress had made this appropriation without having any plans and estimates of cost before it, there seems a probability that the extent of the work to be done had not been realized, and that therefore the best thing to do was to expend only so much of the appropriation as was necessary to prepare an estimate, (which would have to be done even if the appropriation were sufficient to complete the work,) and submit the question again to Congress before proceeding further.

It will not do, however, to take the estimate of the amount required for the Enfield Falls ($870,000) as the sum that will make an equally good navigation all the way from Hartford to Holyoke, and I therefore return to the consideration of the improvement of the river between Hartford and the Enfield Falls. Between these points the river is

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its natural state, at low water has a depth on the bars of about 18 inches, and the effect of the tide is generally imperceptible in the upper parts. The slope of the low-water surface is about $\frac{6}{10}$ foot per mile, the width varying from 500 feet to 1,500 feet, and the volume about 4,000 feet per second.

An application of the Humphreys and Abbot formula (No 38, p. 312, Physics and Hydraulics of the Mississippi River) shows that this volume on this slope is capable of maintaining a section 508 feet wide, with a mean depth of 4 feet, and mean velocity of about 2 feet a second.

It would not be advisable to attempt to make the river at low water narrower than this for the purpose of securing a greater depth. This would be sufficient for the comparatively short period of low water, and a slight rain would easily make a depth of 6 feet, which is the capacity of the locks of the proposed new canal.

The bed of the river is ordinary river-sand, and easily moved by the current. The depth of the bed-rock, or hard pan, beneath this sand, has not been ascertained, although this is an important matter in estimating the difficulty of making any permanent works in the bed of the stream.

Most of the ameliorations to low-water navigation of non-tidal rivers in this country that have been undertaken by "practical men" have been of a temporary nature, designed to afford immediate relief, or at most to last but a season, or till the next rise, and with the expectation that the succeeding spring-floods would carry them away.

Were we to regard the improvement of the navigation from the point of view furnished by the low-water *data* above given, and suppose the river always to remain the same, the improvement of it by confining its low-water bed to a width of 400 or 500 feet would be cheap and simple.

But we must from the beginning take into account the floods of the river, and the violence to which our works for the amelioration of low-water navigation will be subjected in high water. The high-water volume of the river is about 162,000 cubic feet per second. It rises nearly 30 feet above its low stage, overflows its ordinary banks, and spreads out over a broad valley. There are probably maximum velocities of six and seven miles an hour in floods, while at low stages they cannot exceed two and three miles an hour.

The low-water slope, 6-10 foot per mile, which I have given, is the average between Hartford and the Enfield Falls; it is much greater at certain points at low water, but if the river channel is reduced uniformly to a width of 500 feet by artificial works, a uniform slope would result.

The most perfect example of a river reduced to a uniform width with which I am acquainted is the Garonne, in France, which has been thus rectified over a distance of forty-one miles.

The Connecticut is a river of somewhat greater magnitude, but presents no greater difficulties, except in its ice. The ice on the Connecticut is an obstacle to our making use of the simple means of piles and wattling adopted there in the cross of tie banks between their new and old banks of the river, and we must resort almost entirely to riprap, aided by such bond as ordinary brush mingled with it will give.

It is almost obvious that any riprap walls cannot rest permanently on a sandy bed during the floods of the river. Experience has shown in every case that the amount of stone used must be sufficient to take the place of the sand as it is washed out, and sink down till it gets a firm resting-place on the bottom rock. I know of no exception to this rule in practice, and nothing else seems rational.

In the Connecticut River, between Hartford and Enfield Falls, this bed-rock cannot anywhere be less than 10 feet below the low-water surface, and I believe it is much deeper down to it.

Not having thus the data for an accurate estimate, I will present the general features of the improvement by rectifying the channel so as to secure a depth of 4 feet at low water, from which it will appear that this will involve an expenditure between Hartford and the Enfield Falls not less than for the improvement at the falls themselves.

Let us take one of the natural banks as our new rectified river-bank, changing from side to side as may prove best. We must riprap this bank so that its future abrasion shall not take place. Let us suppose that from the bottom of the rock-bed to the top is 27 feet, and make the covering 1 foot thick. This will require 5,280 yards per mile, at $2, $10,560. Our new bank-line must rise 3 feet above low water, be 3 feet wide on top, slope 45° each way, and extend down not less than 13 feet, requiring about 7¼ cubic yards per foot, or 40,920 cubic yards per mile, at $2, $81,840 per mile.

Between our new bank and the old one on the side opposite where we want the channel we must put the same kind of walls normal to our new bank, in order to keep the river from going on that side. These walls should be close together on the upper side of bends where the current is strong, and less so on the lower sides of the points, but cannot be dispensed with there, because of the currents, direct and in eddies. I, however, for this estimate, average the distance for them apart at 500 feet. The sandy bed, being 1,500 feet wide, will require these to be 1,000 feet long. They must be the

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same in strength at least as the new bank-line just estimated for, and there will consequently be required for them 81,840 cubic yards per mile, at $2, $163,680 per mile.

The old bank against which these tie-walls abut will be subject to abrasion both from direct currents and eddies, which will work a channel-way between the tie-walls and itself unless riprapped, and this will take as much stone as for the first main bank, namely, 5,280 yards per mile, at $2, $10,560.

Summing these up, we see that each mile of rectified river will require not less than 133,320 cubic yards, at $2, $266,640; and for ten miles, $2,266,400. To this add, for superintendence, $83,600, and we have a total of $2,750,000.

It thus becomes a question whether it would not be much better to continue the canal down to Hartford, which idea I incline to, though I have no means of making an estimate of the cost of the canal.

I have estimated and planned for a number of works in different parts of the country, and I have always endeavored to present every subject in as favorable light as it would bear, and not to crush a needed work with an exorbitant estimate. But at the same time I have endeavored not to commit the Government to an undertaking without counting the cost.

The foregoing must put the improvement of the Connecticut River in a different light from that in which it has been heretofore contemplated.

If Congress intends to continue such ameliorations of the existing navigation as small appropriations of $20,000 annually will admit of, we must give up the idea of making any new improvements at the Enfield Falls. We must satisfy ourselves with aiding the passage of the river above and below the falls by such vessels as can now pass through the existing canal, and these vessels must continue to pay toll to the canal company. I advise this latter course to be continued at any rate, and that if the grand improvement is contemplated which shall let small Sound-going vessels, small gun and torpedo boats to ascend the river as far as Holyoke, that additional surveys be ordered to further develop the plan as a whole. Of the original appropriation of $20,000 for improvement above Hartford and below Holyoke, we have expended now about $5,500, so that there remains $14,500 that can be applied to additional surveys. If it is to be expended in improvements, I recommend that it be all employed on the river below the Enfield Falls, the first appropriation of $20,000 for this part being about exhausted.

Whether the object to be accomplished, in a national point of view, is commensurate with the expense, is a question of statesmanship. How far the improvement of the Connecticut River, so as to allow small gun-boats and torpedo vessels to patrol it would contribute to natural defense, can hardly be estimated until this valley becomes the theater of actual war. But were the New England States a separate nation they would undoubtedly improve it for this purpose; and as this is a portion of our country that a foreign power would most probably seek to isolate from the rest, it would seem advisable to make it capable of independent defense.

At Springfield there is an important national armory, and at Hartford and other places private manufactories of war material, national in character and importance, though not the property of the Government.

Yours, respectfully,

G. K. WARREN,
Major of Engineers and Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

Survey of Enfield Rapids, Connecticut River, with plans of improvement.

HARTFORD, CONNECTICUT, *January* 10, 1872.

GENERAL: In pursuance of the improvement of the Connecticut River above Hartford, as provided for in the appropriation act for the improvement of rivers and harbors, approved March 3, 1871, a survey has been made of the Enfield Rapids, in the State of Connecticut, with a view to ascertain what improvement can be made at this place to enable boats of a sufficient size to pass, at all times, and at the different stages of the water, to the navigable portion of the river above.

SURVEYS.

The surveys of these rapids have been made during the past season, in connection with the improvements in progress below.

An accurate map of this part of the river has been made, showing the banks and adjacent roads and buildings, and everything that would be likely to be affected by canals upon the banks, or dams constructed across the river bed.

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Sections have been carefully leveled over at distances of about 500 feet apart, extending through the bed of the channel to such a distance on each side as would be likely to be embraced in any proposed improvement.

Bench-marks were established by careful leveling from the low-water gauge-mark at Hartford, and the height taken of all high-water flood-marks that had been preserved by different persons, and of all the lowest water-marks that could be ascertained.

The field-work was in charge of my principal assistant, Mr. Charles L. Burdett, civil engineer, who made the survey of the shore lines, roads, and buildings, and ran the section lines across the river. He also made part of the soundings in the bed of the river.

The levels were taken by Mr. Henry W. Ayres, civil engineer.

Much of the survey of the section lines, and leveling over them, was very difficult, the whole party being sometimes obliged to remain in the water all day.

The deepest parts of the channel on the more level parts of the rapids were sounded from a boat, but the velocity of the current, and the rocky character of the bottom in the more rapid and shoaler portions of the river-bed, rendered the operations of measuring and leveling both difficult and dangerous.

The party consisted at times of sub-assistants Ben. A. Cooke, and George A. Paine 2d, and of Oliver Dening, George T. Arthur, Wilmot Horton, and Eugene L. Avery, who all deserve credit for the willingness with which they performed the disagreeable duty of working in the water, notwithstanding some of them suffered from indisposition in consequence of the continued exposure. The whole party performed whatever duty was required of them, without regard to the capacity in which they were employed. The same party were engaged, when necessary, in field-work on other parts of the river where work was in progress, thus saving the expense of another party on the improvements below, whose services would not be constantly required.

DESCRIPTION OF THE RAPIDS.

The Enfield Rapids commence at a point about sixteen miles above Hartford, Connecticut, and eight miles below Springfield, Massachusetts, and extend down the river to about opposite the village of Windsor Locks, a distance of five and a quarter miles.

At a distance of 10,400 feet below the head of the rapids is King's Island, 5,200 feet in length and 1,650 feet wide, which separates the stream into two parts, the greater volume of water passing to the eastward of the island. The banks of the island are of rock, and its westerly side is a rock-bluff, showing a strata dipping to the northeast at an angle of about 7°. The bank of the river on the easterly side, from the head of the rapids down to near the upper end of the island, is steep, and partly of rock, which is covered with sandy loam. Just above the island the shore is lower and sandy, and is partially overflowed in high freshets. At this place there is a small number of buildings, as shown on the map.

Below this, extending to a point below the New Haven, Hartford, and Springfield Railroad bridge, the bank is again steep and rocky, after which it grows flatter, and is subject to overflow in high freshets.

On this side, at the lower end of the rapids, is the village of Warehouse Point, a part of which along the shore is shown on the map.

Back of the immediate bank, along the easterly side, the ground gradually rises. No streams of any size and but two small brooks enter the river upon this side.

On the westerly side of the rapids is the canal of the Connecticut River Company, which will be referred to hereafter. The tow-path is immediately next to the stream. Beyond the canal, for nearly the whole length, to below the railroad bridge, the ground is mostly high and forms a steep slope, in which the canal forms a side-hill cut, partly of solid rock.

Below the railroad-bridge, at the foot of the rapids, extending for little more than a mile, is the village of Windsor Locks, part of which, along the river, is shown on the map.

For about a mile along the tow-path of the canal, between it and the river, are many large manufacturing establishments, which use the water from the canal for power and discharge it at a lower level into the river.

The track of the New Haven, Hartford and Springfield Railroad passes through the village just west of the canal, running nearly parallel to it, and crossing both it and the river by one bridge above. After crossing the river the railroad keeps upon the east bank, as shown in the map.

Between the villages of Warehouse Point and Windsor Locks there is a swing ferry, near section 9, as shown on the map.

The bed of the stream is rock, and also the banks generally above the island. Below the island the substratum of rock on the banks is covered with sandy loam and gravel. The branch of the river to the westward of the island falls more rapidly at its upper end than the main channel, and is consequently at low water some 5 feet lower near the middle of the island than the surface in the other branch.

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Levels taken over the rapids at a low stage of water, in the month of October last give the total fall from still water above the rapids to still water below at 31.8 feet.

At the foot of the rapids the very lowest water deduced from levels taken at the lowest stage during the past summer, which was an extremely dry season, and the water was probably as low, within about an inch, as ever occurs, is supposed to be 1.4 feet lower than the levels taken in October.

Just above the partial dam at the head of the rapids the water may perhaps fall .2 of a foot below the height when leveled over in October.

Below the dam, according to an authentic low-water mark as the lowest ever reached, the water falls 1.4 feet below the height of surface when leveled over.

At intermediate points between the head and foot of the rapids the lowest water varies from one to two-tenths of a foot to 1.4 feet below the stage when leveled over.

At the lowest stages of the river the water tumbles over the rocky bed in such a manner that the surface sometimes falls laterally across the stream one or two feet, so as to render it difficult to get the relative levels of the lower stages.

From the foregoing it will be seen that at the extreme low water we should have a fall of 33 feet from the surface of the water above the dam to the still water below the rapids.

The surface of the water over the rapids at the lowest stage leveled over is formed of four principal inclines or slopes, two of which are much steeper than the others. Commencing at the upper end of the rapids they are as follows:

Distances.	Fall.	Fall per mile.
Feet.	*Feet.*	*Feet.*
4,800	10.1	11.11
7,600	1.7	1.18
8,800	17.8	10.68
6,500	2.2	1.79

The first slope reaches from the head of the rapids to Enfield bridge; the next to nearly opposite the middle of the island, in the east branch; the next to just below the village of Windsor Locks, and the last to the foot of the rapids.

At higher stages of the water the slope becomes more uniform. When the height of water at Hartford was 10.25 above the 0 of the gauge at the toll-bridge, or about one-third of the greatest height of freshet, the slopes on the rapids were as follows:

Distances.	Fall.	Fall per mile.
Feet.	*Feet.*	*Feet.*
4,800	7.3	8.03
7,600	4.3	2.99
6,800	12.8	9.94
8,500	1.6	.99

As the highest water, or the freshet of May, 1854, which was the greatest freshet ever known on the Connecticut River, the slope was ascertained by levels over the marks of the height of that flood, which have been preserved by different persons, to be as follows:

Distances.	Fall.	Fall per mile.
Feet.	*Feet.*	*Feet.*
9,400	8.9	5.00
10,300	8.7	4.46
8,000	0.0	0.00

The reach called level is averaged through eleven different flood-marks of the freshet of 1854 that were leveled over, none of which were more than .6 of a foot from the average line.

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The high-freshet lines of the years 1854, 1857, and 1869, of which the levels were taken on this part of the river, all seem to make the surface over the lower part of the rapids rise instead of fall.

The slope must be exceedingly small, and the uncertainty of its amount at extreme high water is such that a level is assumed as being practically the surface-line for a distance of 8,000 feet. Below the rapids the slope of the river at extreme low water to Scantic Bar is 1.7 feet in three and a half miles, or .49 foot to a mile. The high-water slope is between the same points .6 of a foot, or .17 foot to a mile.

From Scantic Bar to Hartford, a distance of seven and a half miles, the extreme low-water slope is 4.5 feet, or .6 foot to a mile. The high-water slope between the same points is 2.4 feet, or .32 foot to a mile.

There are two bridges over the rapids, one at Enfield, 4,800 feet below the head of the rapids, with six spans of 124 to 176 feet, and rectangular piers of rubble masonry of poor quality, with a flat slope up stream originally covered with a plank as a protection against ice. The bridge is a wooden lattice, continuous over the piers, and is in a tumble-down and unsafe condition, being in some places very badly strained and warped. The whole is covered with sheathing to protect it from the weather. The bottom of the bridge is 9.2 feet above the tow-path of the canal.

The other bridge, situated 12,200 feet farther down, is that of the New Haven, Hartford and Springfield Railroad. It is a fine iron bridge of recent construction, with cut-stone piers, and spans as follows:

1 of 140 feet, over the canal.
1 of 76 feet, over the tow-path.
1 of 43 feet, called the draw-span.
12 of 84½ feet, over the river.
1 of 177 feet, over the channel.
1 of 25½ feet, over a roadway at the east end.

At the head of the rapids is a dam about 3 feet high, extending nearly across the river, with an opening near the middle of 150 feet, which was originally left for the passage of boats and rafts. The ends of the dam are higher than near the middle.

The opening was passable for boats some twelve or fifteen years ago, but since that time has been gradually filled up year after year with stone thrown in by the Connecticut River Company, until it is now impassable, the water being only about 1½ feet deep where it passes through the dam.

THE CONNECTICUT RIVER COMPANY.

The Connecticut River Company have a canal around the rapids, commencing at the dam above mentioned and following the west bank of the river about five and one-fourth miles to just below the village of Windsor Locks. This canal is constructed on the river bank, outside of the natural bed of the stream, by cutting into the side-hill and forming an embankment upon which is the tow-path. The depth varies from 4½ to 12 feet, and the width from 44 to 160 feet. Above the village of Windsor Locks it is mostly of an average width of about 80 feet, and through the village it will average about 55 feet in width.

At the upper end of the canal is a guard-lock 19.4 feet wide, and 91 feet long between the quoins, for the purpose of admitting boats at high water, and also gates to regulate the flow of water into the canal.

At a distance of 250 feet below Enfield Bridge crossing, there is a set of stop-gates, by which the water above them can be raised five feet to equalize the pressure inside and out, and render the embankment more secure in times of high freshets.

Opposite King's Island the canal crosses over Stony Brook by means of an aqueduct. This has a width of 79.2 feet, and a depth of 5 feet.

At the lower end of the canal there are three lift-locks, of 19 feet width, and 90 feet long between quoins. These locks were poorly constructed, and are at the present time in bad condition. The middle one has the sides pressed inward so as to measure but 18.4 feet in one place.

Through the village of Windsor Locks the water used for manufacturing purposes now furnishes the company its principal revenue. The manufacturing establishments are on the tow-path side of the canal, which is here crowded by the railroad and principal streets of the village, so as to be in one place but 44 feet wide.

The Connecticut River Company was chartered in May, 1824, by the State of Connecticut, with the following powers, among others:

"That the said corporation, for the purpose of widening the channel of said river, and deepening the same, shall have power to dig, cleanse, and remove obstructions from the channels and bars of said river, from and above the bridge, at Hartford, to Springfield, and to erect and build wharves, and piers, and hedges in said river, or on the banks thereof; and the said corporation are empowered to lock the falls at Enfield, on said river, and to make channels to aid them, and to construct a canal on either bank of said river near said falls, and to construct a dam or dams for the purpose of

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entering or leaving the locks in still water: provided, the extension and form thereof shall be such as shall not prevent the convenient passage of boats and lumber down the river, nor obstruct the passage of fish."

The act also provides for a board of three sworn commissioners, "under whose directions the necessary canal shall be laid out, and who shall inspect the construction of the locks and dams in said river, and cause them to be so constructed as they shall not impede the progress of fish up the river, or the passage of floating boats, timber, or any other property down the river."

All the ordinary and necessary powers were given to the company in the act, and the commissioners were given power to inspect the locks, canals, &c., and when out of repair or improperly tended, to direct that no toll be taken until a certificate should be given by them that all necessary repairs were made and suitable lock-tenders employed.

The tolls allowed by this act were 50 cents per ton of loading for ascending boats, and 17 cents per ton for all descending boats and rafts; empty boats passing through the locks, $1.

Vacancies in the board of commissioners were to be filled by the governor, with the consent of the senate.

An addition and amendment, passed in May, 1825, recites that "the capital stock of said company may be expended between Hartford and the north line of this State to Long Meadow, and West Springfield, in the State of Massachusetts, and also to improving the navigation above this State toward the sources of Connecticut River, and toward the Lake Memphremagog, in the State of Vermont, so far as shall be deemed practicable and expedient, lawful authority for so doing being had and obtained; and to this end may purchase, repair, construct, and hold such works as shall be deemed necessary to perfect and complete said navigation."

The same act provides: "The stockholders of the Connecticut River Company, their associates, successors, and assigns, are hereby incorporated and made a body politic, and person in law, by the name of The Connecticut River Banking Company," &c., giving them powers necessary for the business of a banking company. The Connecticut River Company were authorized to organize the Connecticut River Banking Company when they had actually expended the sum of $200,000, and obtained the certificate of the commissioners to that effect.

In May, 1828, an alteration of the charter was passed, authorizing the formation of the Connecticut River Banking Company, when $100,000 had been expended, and providing that the powers of the said banking company shall cease unless a good and navigable canal and locks by Enfield Falls shall be completed by the Connecticut River Company within two years from the rising of the assembly.

In May, 1829, a resolve of the assembly authorized the Connecticut River Banking Company to subscribe to the stock of the Connecticut River Company to the amount of $60,000, and also extended the time for the completion of the locks and canal around Enfield Falls to two years from the rising of that assembly.

In May, 1825, the general assembly of the State of Vermont passed an act, to take effect when assented to and confirmed by the States of Massachusetts, Connecticut, and New Hampshire, incorporating, under certain restrictions, The Connecticut River Company, giving them various powers; among others to purchase land, and to enter into, hold, use, and possess so much of the banks and waters of said river, and the lands adjacent thereto, as shall be necessary for effecting in the best manner the objects of this act, and may dig, cleanse, and remove obstructions from the banks, channels, bars, and rapids of said river; may construct dams, canals, locks, towing-paths, and railways, where it shall be deemed expedient, and other works beneficial to navigation.

This act also gave the company power to purchase the franchises of other corporations for the improvement of the navigation of the Connecticut River, when the proprietors of one-half the stock should agree to sell.

It was also enacted that, as soon as said company shall have constructed suitable and convenient locks and canals, so as to permit the passage of boats of sixty-six feet long and sixteen feet broad, at or near the following places, viz: By Enfield Falls, in the State of Connecticut, near the north part of Hatfield or Hadley, in the State of Massachusetts; at School Meadow Bar, in the States of New Hampshire or Vermont, viz: near Cooper's Rocks, in Hinsdale or Vernon; in Hinsdale or Brattleborough, near the bridge across Connecticut River; in Westmoreland or Putney, near Clay's Island; in Charlestown or Springfield, near Gill's Island; in Cornish or Windsor, near Chase's Island; in Oxford or Fairlee, near Flag Island; in Haverhill or Newbury, near Johnson's Rocks; and also near the mouth of Wells River, in Bath or Ryegate, near Dodge's Falls. And whenever the said company shall have acquired the right to the locks, canals, and works for improving the navigation at South Hadley Falls and Miller's Falls, both in the State of Massachusetts; at Bellows Falls, in New Hampshire and Vermont; at Water Queechy Falls and at White River Falls, they may demand and receive tolls, not to exceed a list given. The rates for Enfield Falls were 50 cents per ton for each ascending boat, and $2 for each descending boat. The company were

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required by this act to maintain a depth of at least 3 feet in the canals and in the river below to the next canal, and below the Enfield Falls Canal to the city of Hartford; "and if the said depth shall not continue without interruption between Enfield Falls and the city of Hartford, the commissioners may reduce or prohibit the taking of tolls." This act was confirmed by the State of Connecticut November 9, 1825, with the limitation, among others, that nothing in it should authorize the company to erect or construct any works which should in any way obstruct or impede the free navigation of the Connecticut River.

At the present time the amount of the capital stock of the Connecticut River Company is $203,500, and its present value is about 50 cents on a dollar, or $101,750.

The tolls now collected are 15 cents per ton for ascending boats, and $2, empty, for descending boats; amounting to about $1,200 a year. The amount received by the company for water-rents is about $15,000 a year.

THE RIVER BELOW THE RAPIDS.

In order to properly consider the nature of the improvement required, it is necessary to know the character of the river and the facilities for navigation above and below the rapids at the present time.

From the mouth of the river to Hartford, a distance of forty-nine miles, the channel is navigable for boats of 8 feet draught at the lowest stages of the water. This is about 2 feet more than the river in its natural state at all times permits. The channel has been materially deepened and widened by the dredging done by the United States Government during the past two seasons.

The navigation, as far up as Hartford, is favored by the tides, which average about 10 inches in height at that place. This rise of tides is in addition to the depths given above, so that boats drawing from 7½ to 8 feet have been for many years used upon this part of the river. The tides at Hartford, however, are not regular, varying from nothing to about 18 inches. Between Hartford and the foot of the rapids, a distance of about eleven miles, the channel is now in a bad condition, owing to bars, upon which there is only from 1½ to 2 feet in the deepest part at the lowest water. The channel is also in many places narrow and crooked.

Works are now in progress by the United States Government which, it is hoped, will deepen the water on the bars to 3½ or 4 feet at low water. Owing to the increased slope of the river-bed, the tides rapidly diminish above Hartford; ordinarily they are not noticeable at Scantic, seven and a half miles above Hartford, but an exceedingly high tide, at a low stage of the river, is sometimes sensible as far up as the foot of the rapids.

There are two bridges below the rapids, both at Hartford. One is the bridge of the Hartford, Providence and Fishkill Railroad, where it crosses the Connecticut; a wooden Howe truss, upon cut-stone piers, in a good state of repair. The other is the highway bridge from Hartford to East Hartford, an old dilapidated affair, in which the subsequent additions barely hold up the original structure. Both of these bridges are provided with draws; that in the railroad bridge has an opening of 47 feet, and that in the highway bridge an opening of 17 feet.

THE RIVER ABOVE THE RAPIDS.

Above the rapids the water is still and level, and good navigation to the village of Holyoke. There is one bar at Long Meadow Flats, upon which there is about 5 feet at low water.

From the points named in the charter of the Connecticut River Company by the State of Vermont, it will be observed that it was contemplated to preserve a navigation of a minimum depth of 3 feet as far up as Wells River, or about two hundred and forty miles. All navigation, however, is now stopped above Holyoke. There was formerly a canal on the east side of the river at this place, extending around South Hadley Falls, but it is now entirely given up, and used only as a tail-race for the mills at its side.

The Holyoke Water Power Company, who built the present dam, have contemplated a new canal on the west side, in connection with their water-power, by which to pass boats around the falls. Their dam and canals are excellent, but the lock which they have put in to descend to the first level is much too small, being but 16 by 80 feet. At this place the whole fall is 58 feet. The first level is 20 feet below the dam; the next level 12 feet lower, leaving 26 feet to the still water below the falls. There is nothing to prevent a good canal being made at this place, as the lock already built can be enlarged without materially interfering with the water-power, and communication can be easily made from the canals to the river below the falls.

Between the head of the Enfield Rapids and Holyoke there is nothing less than 5 feet depth of water in the channel.

There are four bridges on this part of the river—two at Springfield and two above,

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none of which are provided with draws. They are, however, of such a height as to allow small steamboats to pass under them.

The canal at South Hadley Falls, (Holyoke,) and the one at Montague, above, were first chartered February 23, 1792. The dimensions of the locks were to have been 20 by 60 feet, but they were afterward permitted to be built 16 by 40 feet by an act of June 21, 1793. The charters of the two canals were separated February 27, 1794. The South Hadley Canal was first finished; it was two and a half miles long, much of it through solid rock. At first the boats were hauled up an inclined plane by large water-wheels, but the bed of the canal was afterward deepened and locks were used. The lowering of the bed of the canal was completed at the commencement of the year 1805.

The canal at Montague was commenced in 1794, and completed four years afterward, in 1798. It was three miles in length, and reached from above Turner's Falls to the still water below. This canal was used for the transportation of merchandise for about fifty years, until the Connecticut River Railroad was finished, in 1848, when, from the railroad competition and its insufficient size, it was abandoned. It can now scarcely be traced, having been nearly obliterated by more modern improvements.

A new dam has been built by the Turner's Falls Company, and no provision made for water transportation.

THE AMOUNT OF BUSINESS ON THE RIVER.

With regard to the amount of business on the river, no general estimate has been made of the total amount of freight and tonnage since 1867, when one was compiled, chiefly from the evidence given before a committee of the legislature upon the question of bridging the Connecticut River below Hartford. As this is quite reliable, it is given as the best means of computing the present amount of transportation. In 1866 the amount of freight upon the river was as follows:

	Tons.
Steamboats to and from Hartford	74,600
Freights to Hartford by propellers, &c	201,600
Down freight by the same	16,000
Total Hartford freight	292,200
Freight between Hartford and Middletown	24,000
Freight from Portland	220,000
Freight at places below Middletown	79,512
Total	615,712

In 1865 it was 569,000 tons. Allowing 40,000 per year increase, we should have for the year 1871 nearly 816,000 tons of freight passing on the river.

The amount received for freight in 1866 was $1,350,000. At the same rate of increase as for freight above stated in 1871 it would be about $1,800,000.

In 1866 the number of passengers to and from New York by steamboat was	26,211
Way passengers on the river	27,208
By Sag Harbor steamboats	10,000
	63,419
The total amount received from passengers by the steamboat company was	$125,550
By Sag Harbor boat, about	8,000
Total	133,550

The number of trips to and from New York and Hartford by the steamboat company's boats was	1,117
By the Sag Harbor boats	208
By sailing-vessels and propellers	1,836
Total number of trips	3,161

During the past season there have been upon the river five large steamboats, forming two daily lines to New York, and three smaller ones; one making daily trips to New London and Sag Harbor, and another making two trips a day on the river between Hartford and Essex. There is, also, a line of propellers running to Albany, and one to Philadelphia.

The river remains open for navigation an average of nine and a quarter months in

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each year. It closes about the 8th of December, and opens about the 1st of March. For sailing-vessels the time is about eight and a half months.

With regard to the business above Hartford no definite estimate can be made of what would probably pass by water communication instead of by railroad, if the river were navigable to Holyoke by the proposed improvements.

From the size and population of Springfield, Chicopee, and Holyoke, with the great water-power and prospective growth of the latter, it is but fair to presume that the water transportation above Hartford would be considerable, and that all heavy freight, such as iron, coal, stone, bricks, lumber, &c., would be carried by water direct, instead of being transshipped by railroad to the points named. The actual amount of the above materials used has not been ascertained.

AMOUNT OF REVENUE IN THE DISTRICT.

The amount of revenue collected at the Middletown custom-house during the year ending June 30, 1871, was $13,664.79. On June 30, 1871, there were registered in the district 150 vessels, with an aggregate tonnage of 18,458.37 tons. During the year there were built and employed in the district 14 vessels, with a tonnage of 1,964.55 tons.

IMPROVEMENTS OF THE RAPIDS.

In arranging plans for improvement of the Enfield Rapids, the question arises whether any plan should be considered which would entirely close the navigation through the ordinary channel of the river. The charter of the Connecticut River Company, and the concurrence by the Connecticut legislature in the act passed by the State of Vermont in 1825, incorporating the Connecticut River Company, expressly state that nothing shall be construed to empower said company to build a dam at Enfield Falls in such a manner as shall prevent the convenient passage of boats and lumber down the river or obstruct the passage of fish.

Notwithstanding these provisions, the Connecticut River Company have constructed a dam across the river at the head of the falls, which is at present impassable for any purpose of navigation. The opening of 150 feet originally left in the dam has been gradually filled in by the company, until now there is an effectual bar to navigation, unless it be in very high water, when boats might descend.

The channel of the river is now of so little use that there seems to be little or no objection to constructing dams so as to wholly cut off the outside navigation in the natural channel, if the improvement proposed should furnish adequate facilities for the passage of anything that might have occasion to pass the dam. In the plans of improvement proposed, therefore, entire dams across the river will be considered.

With regard to the interference of the franchise of the Connecticut River Company with any plan of improvement, it is assumed that, unless their property is actually taken or their water-power interfered with, no damage will be done to them by withdrawing the navigation from their canal, nor is it supposed they would expect or demand any compensation. The canal at present is totally inadequate to pass such boats as would undoubtedly be used if they could get up the river, and the water transportation has consequently diminished to such an extent through their small locks that the company will probably prefer to give it up altogether, and use their canal entirely for manufacturing purposes if the Government should otherwise improve the navigation over the rapids.

THE DIFFERENT PLANS PROPOSED.

The plans which will be considered for improving navigation over these rapids are:

First. A canal on the west side of the river, extending from the present dam at the head of the rapids, parallel to the old canal, down to a point just above the village of Windsor Locks, and a channel to the deep water below, formed by excavating in the bed of the river.

Second. A canal on the east side of the river from the dam above to the deep water below the rapids.

Third. Damming the river at the island, or a little below it, and continuing with a canal below upon the east side of the river.

Fourth. Damming the river at a point near Enfield bridge, and locking to the river below, damming it again just below the railroad bridge, near Windsor Locks, and continuing with a canal to the foot of the rapids.

Fifth. Improving the old canal so as to be navigable for boats of increased size.

THE FIRST PLAN.

In the first plan it is proposed to make a canal 150 feet wide, parallel to and just outside the old canal, except opposite the island, where it widens out into a basin, with locks 200 feet long between the quoins and fifty feet wide. At the head of the canal a

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guard-lock would be required of the above dimension and 12 feet lift; also a bulk-head of masonry, with gates for regulating the supply of water to the canal.

An embankment of ten feet width on top and slopes of 1½ horizontal to 1 vertical will be required from the guard-lock at the head of the canal down to the upper end of the island. The top of this is intended to be at a level of 2 feet above the freshet of 1854, which is the highest known. This embankment is to have a riprap of rock 2 feet in thickness upon its outer slope, and 1½ feet in thickness upon the top and inside slope. The width of the canal is limited in this part of the river to 150 feet, so as not to encroach too much upon the bed of the stream, and thereby materially diminish the water-way, which is already somewhat contracted.

West of the island the whole of that branch of the river is taken into the canal, the island forming the embankment for about one mile in length, and inclosing a basin of about 600 feet in width. At the foot of this basin, near section 25, shown on the accompanying map, would be the first lock, having a 11 feet lift.

Opposite the island a small stream, called Stony Brook, enters the river, passing under the old canal. Upon this stream, about 1,000 feet from the river, is a water-power of 28 feet fall, having the top of the dam 16.5 feet above the proposed level of the canal basin. The water would have to be turned into the canal, as there seems to be no economical manner of disposing of it otherwise. The water-power would be damaged by reducing the fall to 16.5 feet. The volume of water discharged by this stream during the greatest freshet is about 4,000 cubic feet per second, but only for a very short period of time. At ordinary stages the discharge is, perhaps, not over 100 cubic feet per second.

Near section 25 a dam will cross the westerly channel between the island and the old tow-path. At the west end of this dam it is proposed to place the first lock, while the rest of the dam will serve as a waste-way to dispose of the surplus water coming into the canal from Stony Brook during freshets. The width of this weir would be about 230 feet, and it is believed, from inquiries and observation, that the water running into the reach would never amount to more than 1½ feet in depth over the dam: the large area of the surface of the reach equalizing the sudden rush of water from heavy showers.

The next lock would be about a mile below, near section 15 on the map; near this lock would also be a small waste-weir. This lock would be of similar size and construction to the one above, and of the same lift.

The third and last lock would be situated just above the manufacturing establishments on the old canal bank in the village of Windsor Locks, near the present waste-weir of the old canal. It would be like the others, and of the same lift of 11 feet.

The embankment from the island down to this lock it is proposed in the estimate to make of the same height as the one above, or two feet above the highest water. This embankment between the last two locks might, however, be dropped down to a lower level to lessen the cost, but it would not give so plain an entrance into the canal when the lower lock was flooded.

Below the last lock it is proposed to excavate a channel in the bed of the river for about 4,500 feet in length and 150 feet wide, to a depth of 5 feet at extreme low water, or about 6½ feet at an ordinarily low stage of the river. This channel will lie in such a direction that it can be easily followed.

The rock excavated can be used partly for the embankment above and partly thrown out on the side toward the river, to check the lateral flow of water into the channel, so that the surface of the water within it will have a less slope than the surface of the river. At low water the slope of this part of the river is 2 feet to the mile, which diminishes as the height increases, so that, at 6 feet of water, the slope is 1 foot to the mile, and at high freshets it is practically level.

In this canal it is proposed to make the depth on the miter-sills of the locks 6 feet. In the bed of the canal there will be no depth less than 8 feet.

A tow-path must be excavated on the west side of the island, along the side of the basin, as it is considered desirable to have a continuous tow-path on the embankment side of the canal. It is included in the estimate for this plan.

In the two lower reaches there will be some excavation required to get a depth of 8 feet in the bed of the canal, but the amount is small, and will be more than required in the embankment, which is in excess. The cost of making the canal 8 feet deep is no greater than for a less depth. This canal would pass under Enfield bridge, leaving 19 feet above the surface, and under the railroad bridge, leaving about 29 feet.

There are no draws in these bridges, but the railroad bridge has what is called a "draw-span," under which the canal would pass. The charter of the company obliges them to have a draw, but the navigation of the river outside the old canal has never compelled them to comply with it. If the new canal should be constructed, they would probably put a draw at this place. A road-bridge will be required at the lower end, over the canal, and a bridge over the top of the waste-dam at the upper lock. The length of this improvement would be 4.85 miles.

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THE SECOND PLAN.

The second plan of a canal on the east side of the river would lose the advantage of about one mile of embankment, which is formed by the island in the proposed canal on the west side, but it could be continued lower down the river entirely to the foot of the rapids without interfering with the use of the old canal for manufacturing purposes, and thus dispense with the large amount of excavation in the bed of the river. Even if turned into the river as high up as would be required on the west side, it presents an advantage, as the natural channel of the river is upon the east side, and might be used without any excavation, but it is considered too shallow and intricate for good navigation. In this plan the guard-lock and bulk-head, with entrance-gates for the water, would be the same as by the first plan. From the head of the canal the embankment would be mostly in the river down to section 40; the canal would then pass out of the bed of the river, and cut into the bank down to section 31. It then again runs in the river to section 25, after which it cuts into the bank, passing under the railroad just east of the present bridge, and continuing back of the river-bank to section 4, where it enters the channel. There will be some rock-cutting to form a channel above and below Enfield dam, and also below the canal near section 4.

There will be three lift-locks of the same dimensions as before named, viz, 50 by 200 feet, below the railroad bridge. The first near section 20, the second near section 7, and the third near section 4 at the end of the canal.

This canal is of the same width proposed for the other, viz, 150 feet. The two lower locks would be flooded at high water, but a flood that would cover more than the first is extremely rare.

The reason for cutting into the bank and passing under the railroad, instead of following around the river-bank, is that for some distance above the bridge the bank is very much exposed to floating ice, which often piles up to a great thickness at this place, so that an embankment outside would be liable to destruction from this cause.

Below the bridge, through the village of Warehouse Point, the canal is kept back from the river to such a distance that the level of the water in it will not overflow and cover ground behind it, nor require any material quantity of embankment on the inside.

By dropping to the lower reach sooner the canal can be run along shore; but unless the embankment be carried above high water, the lower part of the canal would be occasionally overflowed and the entrances blind through the drowned portion.

This canal will require three waste-weirs near sections 5, 6, and 16.

The surface of the water in the canal will be 19 feet under Enfield bridge, and 23 feet under the level of the track where it crosses the railroad.

A road in the village of Warehouse Point will have to be moved or closed, and some houses in the village will also require removal.

There will be required at least two bridges over the canal at Warehouse Point: one, a road-bridge, at the cross-street upon which the hotel is situated, and one (perhaps a foot-bridge) on the cross-street below. A small stream near section 19 will be carried under the canal by a culvert. Another small brook, at section 36, will be turned into the canal. All other surface-drainage will be carried into the canal.

Below the lower lock there will be some excavation required in the bed of the river to get a clear depth of 6 feet. This is provided for in the estimate. The length of this canal would be 4.83 miles.

THE THIRD PLAN.

The third plan of damming the river at the island, and constructing a canal on the east side to below the rapids, requires one dam of 1,150 feet in length and 17 feet high on the east side of the island, near section No. 26, as shown on the map, and another at the head of the island, crossing the west branch diagonally from the end of the island to the opposite shore above, of about 600 feet in length and 13 feet high. Both of these dams are of the same height as the Enfield dam. This height would bring the top of the dam at the head of the island within 1 foot of the top of the tow-path of the old canal. As the proposed dam would have about 10 feet of water flowing over it in the highest freshets, the bank of the old canal must be at least 12 feet above, or 11 feet higher than it is now at this place. This height would have to be continued up the river, along the continually rising slope of the tow-path, to the upper end of the old canal, a distance of 9,000 feet, where the filling would be about ¼ foot.

As, however, the usefulness of the old canal for purposes of navigation would cease upon the construction of more extended works by the Government, it will be better to continue the dam directly across the old canal, and arrange gates to admit and regulate the proper quantity of water needed for manufacturing purposes. This will be much cheaper than the long and heavy embankment required, and would be free from the great risk of leakage and rupture during freshets that would be incurred with the embankment. The old canal would be much safer than it is now, as much of the present tow-path is below the highest flood. By this plan the under side of the bridge at

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Enfield would come quite near the surface at high water. In the two preceding plans the water is confined to the canal, and does not rise with the river. Supposing the water to run over the dams 10 feet deep, it would leave a distance of only 9 feet under the bridge. At ordinary high water very few boats, if any, could pass. With this plan, therefore, the bridge would have to be raised or provided with a draw.

From the lower dam, at section 26, to the foot of the rapids, there would be a canal on the east side of the river, the same as in the second plan.

The guard-lock would be at the dam, and would have a 10-feet lift. The other locks would be exactly the same as before described.

The dams are estimated to be made of 12-inch by 12-inch chestnut timber, laid up in a cob-work, inclining at an angle of 2½ horizontal to 1 perpendicular, bolted together with iron bolts, and filled in solid with blocks of stone. The top surface is a complete layer of 12-inch timbers.

As these dams are so situated that the dip of the strata of the underlying rock is up stream, they will not be endangered by any excavation the water may make below them. They consequently will not need any apron or other expensive structure below, such as has been recently added to the Holyoke dam.

At the east end of the east dam, near the guard-lock, there would be entrance-gates for the water, the same as at the upper end of the canal by the previous plans. The length of canal required by this plan would be 2.13 miles.

In place of the two dams above mentioned, one might be built just above the railroad-bridge, near section 22, as shown on the map. This dam would be about 1,300 feet long and 23 in height. Like the one at the head of the island, it would have to cross the canal also, and be supplied with gates to let the water into the old canal. This is the lowest down the river that a dam of the level of the Enfield dam can be built. It cannot be placed below the railroad bridge, on account of the height of the bottom chord of the channel-span, which is only 4½ feet above the required height of the dam, or 7½ feet below high water.

The bottom chords of the twelve river spans of 88½ feet would also be 3 feet under water in the highest freshets.

A dam as proposed, between the railroad bridge and the island, would set the water back in Stony Brook so as to damage the mill privilege, as mentioned in the first plan, diminishing the fall from 28 feet to 16.5 feet. The length of canal required by this plan would be 1.64 miles.

The estimates for the third plan are marked *a* and *b* for the two modifications above described.

THE FOURTH PLAN.

The fourth plan proposed requires two dams at different levels. The upper one is placed just above Enfield bridge, near section 46, so that the lower level reaching under the bridge would give a greater headway than in the previous plan. The top of this dam would be of the same level as low water above the rapids.

The next dam is placed at 11 feet lower level, just below the railroad bridge, near section 21. This is done with a view to passing under the bridge already built, instead of making a new one east of it. If the dam is placed above the bridge, the masonry of the locks would contract the water-way, and be too much exposed to damage from ice, unless moved back so that the canal would pass east of the bridge, as in the before-proposed plans.

The average height of the upper dam would be about 10½ feet, and the lower one about 13 feet.

The upper dam would be about 950 feet in length, and the lower one 1,200 feet.

At the upper dam there would be a guard-lock of 15 feet lift, and a lift-lock of 11 feet. These are best placed at the west end of the dam.

At the lower dam there would also be a guard-lock of 12½ feet lift, and a bulkhead with gates leading into the canal.

The canal in this plan passes along the bank of the river from the lower dam down to near section 4, as shown on the map, 150 feet wide, as in the other plans.

Through the village of Warehouse Point it would run in the river just outside of the river-road, and the water would be nearly up to the level of the road.

The embankment would be of the same character as heretofore described, and carried up 2 feet above high water.

There would be two lift-locks of 11 feet each between sections 6 and 4 at the lower end of the canal.

All the locks are of the same length and width as before described, but by this plan one more lock is required, viz, the guard-lock at the lower dam.

Two waste-weirs are needed just above the two lower locks, and a foot-bridge across the canal from the shore to the embankment.

This plan gives a height of 30 feet under Enfield bridge at low water, or 17½ feet at high water, and under the railroad-bridge a height of 28½ feet at the draw-span, and 20 feet under the twelve river-spans at low water, or 16½ and 7½ feet respectively at

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high water. There is a narrow span of 25 feet at the east end of the bridge, which might be made available at high water, under which there would be 18½ feet at the highest stages.

This plan would require the raising of the bank of the old canal, on account of the higher level to which the freshet-line would be raised. From the upper dam to the head of the old canal there would be about 3,500 feet, including the guard-lock, which would be overflowed, and would have to be raised an average of 5 feet, and between the two dams there would be about 10,000 feet requiring to be raised an average of 2 feet.

The upper dam can, however, be carried across the canal, and provided with gates, as described for the third plan, so as not to require any alteration of the canal above the dam. This is the method provided for in the estimates.

The pond of the lower dam at the lowest water will cause back-water to the extent of about .5 of a foot at the lower water-privilege on Stony Brook.

Some excavation will be required in the bed of the stream below the locks at the upper dam.

Below the canal there would also be required some rock excavation in the bed of the river, to get a clear depth of six feet. These are included in the estimate.

The length of canal required by this plan would be 1.50 miles.

THE FIFTH PLAN.

In the fifth plan of enlarging the old canal, it is proposed to widen it to 150 feet, so as to give the same facilities to navigation as the other plans, by excavating upon the west side of the canal, and putting material upon the present tow-path, which is now a great deal too low, and in many places exceedingly weak.

At Enfield bridge, and at the railroad-bridge crossing the canal, it is proposed to leave the abutments as they are. The span of the bridge at Enfield is 124 feet, one pier being on the tow-path embankment. The span of the railroad-bridge is 140 feet, with the pier likewise on the present tow-path. These spans will allow sufficient space, although not so wide as the rest of the proposed canal.

The aqueduct where the canal crosses Stony Brook it is not proposed to alter. It is 79.2 feet wide, with water 5 feet deep, and is in pretty good repair. It would not probably be necessary to provide a new structure for many years.

Below the railroad-bridge the track would have to be moved to the westward, to accommodate the increased width of the canal, as shown on the accompanying map. Where it crosses the small water-course, just above the village, it will not be changed.

Through the village of Windsor Locks, the position of the canal is contracted, the width being much less than in other parts. On the east side it is limited by the tow-path, on which many large manufactories have been erected, and on the west side it is crowded by the track of the New Haven, Hartford and Springfield Railroad, and by the main street of the village. On this part of the canal it is proposed to widen to the required distance by taking property on the opposite side of the street, and moving over both the street and the railroad, as shown by the blue lines on the map. This will take all the buildings on the street between Burnap's hall and Browning's drug-store, requiring them to be taken down or moved back to the new line. Below this for some distance the houses stand back from the street, so that no buildings will be disturbed; but from Elm street to South street several more houses will require removal. These are shown on the map.

The railroad will be moved so as to run parallel to the canal on its west bank, and the new highway placed beyond it. At the present time this road is exceedingly unsafe, being for some distance nearly on a level with the track, and close to it. At one point the whole road and railroad occupies a space of only about 70 feet from the bank of the canal. With regard to safety and the general appearance of the street, it is believed that the proposed change will be a benefit.

The alterations proposed interfere somewhat with the railroad in giving less space for buildings, turn-outs, &c. It will also oblige the company to move the station-buildings to another locality.

It will also cause the removal of the store-house of the Seymour Paper Company, near the railroad-buildings, and the Dexter Mill farther down on the west bank of the present canal.

The bridges estimated for in this plan are of a similar character to those now used, which are but little elevated above the surface of the water, and are swing or floating bridges, used when boats are not passing.

The stop-gates which have been recently placed in the canal, just below Enfield bridge, will have to be removed.

A new guard-lock, of the dimensions before described, is to be constructed at the upper end of the canal. At the lower end new locks of the same dimensions are to be built. These will, on account of their size, be placed farther apart than those of the present canal. It is proposed to locate them a little to the west of the present position,

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so that they can be constructed without interrupting navigation through the old locks. In this plan the franchise of the Connecticut River Company will have to be purchased by the Government, and there is no doubt that it could be obtained at a fair valuation, as the greater part of the stock is held by the Connecticut River Banking Company, and by the family of the president of the canal company. It could probably be bought for about $100,000.

An estimate is made upon this plan for a canal of 150 feet wide, in order to compare with the other proposed plans. This can be modified to save expense, even to narrowing down to the present width of the canal. In this case the cost would be reduced to the expense of putting in the new locks and the cost of purchasing the franchise of the old canal company. This might be all that would be required for some years, until the increased size of boats passing through the canal should necessitate its being widened.

An estimate has been made on this modification, and the two estimates for this plan marked *a* and *b*.

NO PLAN FOR IMPROVING THE NATURAL CHANNEL.

No plans or estimates are presented for improving the natural channel of the river by excavation or otherwise, because such a work would not meet the requirements of the river navigation, and would probably prove more expensive than those proposed. It will be seen in the description of the rapids that, at a low stage of the river, the slope over part of the channel is 11.11 feet per mile for a distance of 4,800 feet, and 10.68 feet per mile for 8,800 feet. An excavation in the bed of the river, or parallel embankments, to carry all the water, would form a mere chute, impracticable for ascending or descending boats. The mean velocity of the current would be about 5.2 miles per hour, and a channel 6 feet deep and 88 feet wide would carry all the water in the river at the lowest stages when running with this velocity.

ESTIMATES.

The following estimates are made for a canal 150 feet wide at the water-line, with slopes of 1½ horizontal to 1 vertical, both in the cuts and for the embankments. These latter are supposed to be of earth raised in layers, so as to be water-tight without a separate clay puddling in the middle, and to have a riprap of rock upon the outside slope of 2 feet in thickness, and on the inside slope and top of 1½ feet in thickness.

The canals are all estimated as 7 feet deep, with 6 feet of water on the miter-sills when the water is at its minimum level.

The masonry of the locks is supposed to be coursed rubble, of freestone, laid in hydraulic cement and grouted, with the gate-chambers, quoins, coping, and corners of all the masonry in the locks of cut granite.

The masonry for the railroad-bridge abutments, entrance-gates at the heads of the canals, waste-weirs, and the abutments of the proposed dams are estimated as all of coursed freestone rubble, with corners and coping having cut beds and builds. The other bridge-abutments are estimated of uncoursed rubble, of stone in the vicinity, with similar cut corners and coping.

The retaining-walls are estimated as uncoursed rubble, laid in cement like the preceding.

The lock-gates are supposed to be of ordinary construction, with white-oak timbers and pine sheathing, and to be opened and closed by capstans. All the dams are supposed to be constructed of a cob-work of 12-inch by 12-inch chestnut timber, with a vertical face and a back slope of 2½ horizontal to 1 vertical, laid on the incline, with cross-intersections at 5-feet distances, and the whole filled in solid with broken stone. The surface of the sloping back is estimated as of solid timber, 12 inches thick. The intersections of all the timbers to be bolted through with 1-inch iron bolts. No aprons below the dams are included, as they are not considered necessary.

The embankments are all estimated as 2 feet above the highest water. No account is taken of the slopes of the water-surface in the canals or between the dams. The reaches are considered level for the purposes of an estimate. This will be sufficiently exact until the plan to be executed is determined upon, when the proper slope and all the details of the work can be accurately arranged.

Estimate for first plan.

419,720 cubic yards earth embankment, at 45 cents	$193,374
81,750 cubic yards rock embankment, at $2	163,500
3,500 cubic yards earth excavation, (foundations,) at 60 cents	2,100
5,725 cubic yards rock excavation, (foundation,) at $3	17,175
101,100 cubic yards rock, channel below canal, at $4	404,400
3,002 cubic yards rock-filling for waste-dam, at $2.50	7,505

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1,200 cubic yards clay puddling, at $1.50	$1,800
3,330 cubic yards rubble in guard-lock, at $12	39,960
676 cubic yards cut stone in guard-lock, at $20	13,520
3,315 cubic yards rubble in first lift-lock, at $12	39,780
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,315 cubic yards rubble in second lift-lock, at $12	39,780
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
350 cubic yards rubble in gate-head, at $12	4,200
100 cubic yards cut stone in gate-head, at $16	1,600
950 cubic yards rubble in waste-dam, at $12	11,400
200 cubic yards cut stone in waste-dam, at $16	3,200
130 cubic yards rubble in two waste-weirs, at $12	1,560
30 cubic yards cut stone in two waste-weirs, at $16	480
400 cubic yards rubble in road-bridge abutments, at $8	3,200
100 cubic yards cut stone in road-bridge abutments, at $16	1,600
1,320 cubic yards rubble in retaining-walls, at $8	10,560
2,700 cubic yards concrete, at $5	13,500
408,000 feet (board-measure) timber in waste-dam, at $45	18,360
36,800 pounds iron bolts in waste-dam, at 10 cents	3,680
100 feet bridge superstructure, at $50	5,000
500 feet bridge over dam, at $10	5,000
8 pairs lock-gates	22,500
2 waste-weirs	3,500
Gates at entrance to canal	1,500
Gate-house	750
Coffer-dam, &c	15,000
Alteration of dam at Enfield	5,000
Labor, &c., on dam not included	26,500
Land damages	25,000
Engineering and contingencies, 10 per cent	117,624
Total	1,293,868

Estimate for second plan.

292,000 cubic yards earth embankment, at 40 cents	$116,800
66,160 cubic yards rock embankment, at $1.75	115,780
154,000 cubic yards earth excavation, at 35 cents	53,900
4,000 cubic yards rock excavation, (foundations,) at $3	12,000
8,300 cubic yards rock, channel above dam, at $5	41,500
7,400 cubic yards rock, channel below dam, at $5	37,000
5,500 cubic yards rock, channel below canal, at $5	27,500
1,200 cubic yards clay puddling, at $1.50	1,800
2,904 cubic yards rubble in guard-lock, at $12	34,848
676 cubic yards cut stone in guard-lock, at $20	13,520
3,115 cubic yards rubble in first lift-lock, at $12	37,380
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,115 cubic yards rubble in second lift-lock, at $12	37,380
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
350 cubic yards rubble in gate-head, at $12	4,200
100 cubic yards cut stone in gate-head, at $16	1,600
200 cubic yards rubble in three waste-weirs, at $12	2,400
40 cubic yards cut stone in three waste-weirs, at $16	640
600 cubic yards railroad-bridge abutments, at $12	7,200
200 cubic yards cut stone in railroad-bridge abutments, at $16	3,200
400 cubic yards rubble in road-bridge abutments, at $8	3,200
100 cubic yards cut stone in road-bridge abutments, at $16	1,600
240 cubic yards rubble in foot-bridge-abutments, at $8	1,920
60 cubic yards cut stone in foot-bridge abutments, at $16	960
450 cubic yards culvert masonry, at $10	4,500
1,630 cubic yards retaining-walls, at $8	13,040
1,800 cubic yards concrete, at $5	9,000
100 feet bridge superstructure at railroad, at $80	8,000
100 feet bridge superstructure, at $50	5,000
100 feet bridge superstructure, at $25	2,500
8 pairs of lock-gates	22,500

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3 waste-weirs	$5,200
Gates at entrance to canal	1,500
Gate-house	750
Alteration of dam at Enfield	5,000
Coffer-dams, &c	12,000
Land damages	75,000
Engineering and contingencies, 10 per cent	79,058
Total	869,636

Estimate for third plan, (a.)

169,800 cubic yards earth excavation, at 35 cents	$59,430
4,000 cubic yards rock excavation, at $2	8,000
1,550 cubic yards rock excavation, (foundations,) at $3	4,650
5,500 cubic yards rock, channel below canal, at $5	27,500
1,972 cubic yards filling for west dam, at $2.50	4,930
8,674 cubic yards filling for east dam, at $2.50	21,685
3,000 cubic yards clay puddling, at $1.50	4,500
2,800 cubic yards rubble abutments, west dam, at $12	33,600
800 cubic yards cut-stone abutments, west dam, at $16	12,800
2,600 cubic yards rubble abutments, east dam, at $12	31,200
400 cubic yards cut-stone abutments, east dam, at $16	6,400
4,140 cubic yards rubble in guard-lock, at $12	49,680
614 cubic yards cut stone in guard-lock, at $20	12,280
3,115 cubic yards rubble in first lift-lock, at $12	37,380
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,115 cubic yards rubble in second lift-lock, at $12	37,380
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
350 cubic yards rubble in gate-head, at $12	4,200
100 cubic yards cut stone in gate-head, at $16	1,600
200 cubic yards rubble in three waste-weirs, at $12	2,400
40 cubic yards cut stone in three waste-weirs, at $16	640
600 cubic yards rubble in railroad-bridge abutments, at $12	7,200
200 cubic yards cut stone in railroad-bridge abutments, at $16	3,200
400 cubic yards rubble in road-bridge abutments, at $8	3,200
100 cubic yards cut stone in road-bridge abutments, at $16	1,600
240 cubic yards rubble in foot-bridge abutments, at $8	1,920
60 cubic yards cut stone in foot-bridge abutments, at $16	960
450 cubic yards culvert masonry, at $10	4,500
1,580 cubic yards retaining-walls, at $8	12,640
2,700 cubic yards concrete, at $5	13,500
396,600 feet (board-measure) timber for west dam, at $45	17,847
1,473,600 feet (board-measure) timber for east dam, at $45	66,312
39,360 pounds iron bolts for west dam, at 10 cents	3,936
137,600 pounds iron bolts for east dam, at 10 cents	13,760
100 feet of bridge superstructure, at $80	8,000
100 feet of bridge superstructure, at $50	5,000
8 pairs of lock-gates	22,500
100 feet of bridge superstructure, at $25	2,500
3 waste-weirs	5,200
2 gate-houses	1,500
Gates at entrance of new canal	1,500
Gates at entrance of old canal	1,200
Alteration of Enfield bridge	15,000
Coffer-dams, &c.,	12,000
Fish-way at east dam	1,700
Labor, &c., on west dam not included	43,000
Labor, &c., on east dam not included	84,000
Land damages	90,000
Engineering and contingencies, 10 per cent	87,419
Total	961,609

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Estimate for third plan, (b.)

154,200 cubic yards earth excavation, at 35 cents	$53,970
1,525 cubic yards rock excavation, (foundations,) at $3	4,575
5,500 cubic yards rock, in channel below canal, at $5	27,500
19,530 cubic yards rock, filling in dam, at $2.50	48,825
2,000 cubic yards clay puddling, at $1.50	3,000
4,200 cubic yards rubble in abutments of dam, at $12	50,400
1,200 cubic yards cut stone in abutments of dam, at $16	19,200
5,766 cubic yards rubble in guard-lock, at $12	69,192
676 cubic yards cut stone in guard-lock, at $20	13,520
3,115 cubic yards rubble in first lift-lock, at $12	37,380
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,115 cubic yards rubble in second lift-lock, at $12	37,380
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
350 cubic yards rubble in gate-head, at $12	4,200
100 cubic yards cut stone in gate-head, at $16	1,600
200 cubic yards rubble in three waste-weirs, at $12	2,400
40 cubic yords cut stone in three waste-weirs, at $16	640
600 cubic yards rubble in railroad-bridge abutments, at $12	7,200
200 cubic yards cut stone in railroad-bridge abutments, at $16	3,200
400 cubic yards rubble in road-bridge abutments, at $8	3,200
100 cubic yards cut stone in road-bridge abutments, at $16	1,600
240 cubic yards rubble in foot-bridge abutments, at $8	1,920
60 cubic yards cut stone in foot-bridge abutments, at $16	960
450 cubic yards culvert masonry, at $10	4,500
1,580 cubic yards retaining-walls, at $8	12,640
2,700 cubic yards concrete, at $5	13,500
2,637,000 feet (board-measure) timber in dam, at $45	118,665
229,380 pounds iron bolts in dam, at 10 cents	22,938
100 feet bridge superstructure, at $80	8,000
100 feet bridge superstructure, at $50	5,000
100 feet bridge superstructure, at $25	2,500
4 pairs of lock-gates	22,500
3 waste-weirs	5,200
2 gate-houses	1,500
Gates at entrance to new canal	1,500
Gates at entrance to old canal	1,200
Altering Enfield bridge	15,000
Coffer-dams, &c	5,000
Fish-way	2,300
Labor, &c., on dam not included	156,000
Land damages	100,000
Engineering and contingencies, 10 per cent	96,006
Total	1,056,071

Estimate for fourth plan.

33,440 cubic yards earth embankment, at 45 cents	$150,498
51,792 cubic yards rock embankment, at $2	103,584
3,125 cubic yards rock excavations, (foundations,) at $3	9,375
11,000 cubic yards rock in channel at upper dam, at $5	55,000
36,000 cubic yards earth, raising old tow-path, at 45 cents	16,200
31,500 cubic yards rock, raising old tow-path, at $2	63,000
2,238 cubic yards filling in upper dam, at $2.50	5,595
4,860 cubic yards filling in lower dam, at $2.20	12,150
5,500 cubic yards rock, channel below canal, at $5	27,500
3,000 cubic yards clay puddling, at $1.50	4,500
3,000 cubic yards rubble in upper dam, at $12	36,000
700 cubic yards cut stone in upper dam, at $16	11,200
1,800 cubic yards rubble in lower dam, at $12	21,600
400 cubic yards cut stone in lower dam, at $16	6,400
5,194 cubic yards rubble in upper guard-lock, at $12	62,328
768 cubic yards cut stone in upper guard-lock, at $20	15,360
3,702 cubic yards rubble in lower guard-lock, at $12	44,424
691 cubic yards cut stone in lower guard-lock, at $20	13,820
2,633 cubic yards rubble in first lift-lock, at $12	31,596

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645 cubic yards cut stone in first lift-lock, at $20	$12,900
3,838 cubic yards rubble in second lift-lock, at $12	46,056
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,633 cubic yards rubble in third lift-lock, at $12	31,596
645 cubic yards cut stone in third lift-lock, at $20	12,900
350 cubic yards rubble in gate-head, at $12	4,200
100 cubic yards cut stone in gate-head, at $16	1,600
130 cubic yards rubble in two waste-weirs, at $12	1,560
30 cubic yards cut stone in two waste-weirs, at $16	480
240 cubic yards rubble in foot-bridge abutments, at $8	1,920
60 cubic yards cut stone in foot-bridge abutments, at $16	960
1,350 cubic yards retaining-walls, at $8	10,800
2,700 cubic yards concrete, at $5	13,500
519,800 feet (board-measure) timber in upper dam, at $45	23,391
996,200 feet (board-measure) timber in lower dam, at $45	44,829
52,290 pounds iron bolts, in upper dam, at 10 cents	5,229
98,880 pounds iron bolts in lower dam, at 10 cents	9,888
100 feet bridge superstructure, at $25	2,500
10 pairs lock-gates	28,500
2 waste-weirs	3,500
Gates at entrance to canal	1,500
Gates at entrance to old canal	1,200
Gate-house	750
Coffer-dams, &c	15,000
Fish-ways at dams	2,400
Labor, &c., on upper dam not included	39,000
Labor, &c., on lower dam not included	57,000
Land damages	35,000
Engineering and contingencies, 10 per cent	111,119
Total	1,222,308

Estimate for fifth plan, (a.)

1,524,300 cubic yards earth excavation, at 30 cents	$457,290
462,000 cubic yards rock excavation, at $1.50	693,000
3,000 cubic yards rock foundation, at $3	9,000
1,200 cubic yards clay puddling, at $1.50	1,800
3,330 cubic yards rubble in guard-lock, at $12	39,960
676 cubic yards cut stone in guard-lock, at $20	13,520
3,120 cubic yards rubble in first lift-lock, at $12	37,440
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,120 cubic yards rubble in second lift-lock, at $12	37,440
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
400 cubic yards rubble in four road-bridges, at $8	3,200
225 cubic yards rubble in three foot-bridges, at $8	1,800
8,680 cubic yards rubble in retaining-walls, at $8	69,440
2,700 cubic yards concrete, at $5	13,500
4 road-bridges	6,000
3 foot-bridges	3,000
Removing stop-gates	500
Moving railroad-track	1,500
Altering highway	500
8 pairs of lock-gates	92,500
Coffer-dams, &c	5,000
Land damages	155,000
Engineering and contingencies, 10 per cent	164,165
	1,805,815
Add value of old canal	101,750
Total	1,907,565

Estimate for fifth plan, (b.)

48,000 cubic yards earth excavation, (foundations,) at 50 cents	$24,000
3,000 cubic yards rock excavation, (foundations,) at $3	9,000
1,200 cubic yards clay puddling, at $1.50	1,800

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3,330 cubic yards rubble in guard-lock, at $12	$39,960
676 cubic yards cut stone in guard-lock, at $20	13,520
3,120 cubic yards rubble in first lift-lock, at $12	37,440
645 cubic yards cut stone in first lift-lock, at $20	12,900
3,120 cubic yards rubble in second lift-lock, at $12	37,440
645 cubic yards cut stone in second lift-lock, at $20	12,900
2,630 cubic yards rubble in third lift-lock, at $12	31,560
645 cubic yards cut stone in third lift-lock, at $20	12,900
2,700 cubic yards concrete, at $5	13,500
8 pairs of lock-gates	22,500
Removing stop-gates	500
Coffer-dams, &c	5,000
Engineering and contingencies, 10 per cent	27,492
	302,412
Add value of old canal	101,750
Total	404,162

RECAPITULATION OF ESTIMATES.

First plan:	
Canal and channel on west side	$1,293,868
Second plan:	
Canal on east side	869,636
Third plan, (*a*:)	
Two dams at island and canal	961,609
Third plan, (*b*:)	
One dam below island and canal	1,056,071
Fourth plan:	
Two dams, at different levels, and canal	1,222,308
Fifth plan, (*a*:)	
New locks and widening old canal	1,907,565
Fifth plan, (*b*:)	
New locks only, old canal	404,162

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MATERIALS FOR THE WORK.

Earth and rock for the embankments in the first, second, and fourth plans will be easily obtained upon the banks in the vicinity of the work. In the other plans proposed the cutting will equal the filling, or be in excess.

Stone for part of the rubble masonry can probably be obtained of sufficiently good quality in the vicinity.

The cut blocks of freestone for the corners and coping, and the larger blocks of stone for the abutments of the dams, will probably be best obtained from the quarries at East Windsor, about two miles below the foot of the rapids, where blocks of excellent quality and any desired size can be obtained. There are also other quarries at Portland and other places on the river where the stone could likewise be conveniently obtained.

The granite used in the locks would have to be brought from Munson, Massachusetts, or from Westerly, Rhode Island, at both of which places there are excellent quarries. The latter would probably be the best, as there is water communication nearly the whole distance.

The timber for the dams, lock-gates, weirs, &c., can be best obtained in Vermont and New Hampshire, and brought down by railroad directly to where it is to be used. Timber cannot at the present time be rafted down the river past Turner's Falls and Holyoke.

The iron work, both cast and forged, for the locks and dams, can be prepared at Hartford, where there are extensive shops and foundries, and transported by water or rail as is most convenient.

ADVANTAGES AND DISADVANTAGES OF THE PROPOSED IMPROVEMENTS.

Each of the improvements proposed has some especial advantages or disadvantages which it will be well to consider irrespective of the cost.

The first plan proposed, that of a canal on the west side of the river, has the benefit of the channel west of the island to form a large and commodious basin, valuable for various purposes in a canal, but more especially as a safe winter-harbor for the river-boats, where they would not be endangered by the ice in the spring freshets.

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It also has the advantage of passing under the railroad-bridge at the most favorable place for width and head-room, and where the company would be required to build a draw, if one should be deemed desirable. This plan leaves the natural channel open for descending boats.

The disadvantages of this plan are that it is upon the outside of the old canal, and nowhere accessible from the shore except by bridges over the old canal. This would be very important to boats loading and unloading at Windsor Locks, or to those lying in the basin west of the island. Also, that the new canal cannot extend to the deep water at the foot of the rapids on account of the great value of the mills and manufacturing operations making use of the water-power of the old canal. The excavated channel below the last lock would be more difficult of navigation than the canal extended down the same distance. This plan furnishes no good landing at Windsor Locks, and little or no additional water-power. It materially diminishes the sectional area of the water-way above the island, even with the proposed width of 150 feet.

The second proposed plan of a canal on the east side of the river has the advantage of being next to the shore, with convenient access to all parts of it. It passes under the railroad, where a draw can be built, if desired, although the whole expense would probably fall on the Government. It can extend to the foot of the rapids, and will open into the river on the channel side. It also falls abruptly at the lower end, so that a very short length will be flooded even in the highest water. The entrance will be easily accessible at all stages of the river.

This plan will also provide an abundant water-power, which will be second to none in the State, and furnishes an excellent location for manufacturing-establishments between the canal and river, at Warehouse Point.

This plan also leaves the natural channel of the river open for descending boats, and it is the only plan that does not touch or interfere in any manner with the old canal.

The disadvantage of this plan, as well as the previous one, is that it materially diminishes the sectional area of the bed of the river. It also has the disadvantage that, if the canal is to be made deeper than proposed, there will be much more rock-cutting in the channel above and below Enfield Dam.

The third proposed plan of a dam on each side of the island, and a canal below on the east side, has the advantage of not contracting the water-way above the island, like the two preceding plans. It also shortens the canal on the east side of the river to 2.13 miles. In this plan the canal can be wider, if hereafter considered desirable. This plan has also the same advantage regarding water-power as the preceding.

The disadvantages of this plan are: It closes the natural channel of the river, which has been heretofore deemed an important matter. It is open to the objection of the insecurity to which all dams are subject, and their being of far less permanent character and liable to more repairs than a canal.

In this plan also boats endeavoring to enter the upper lock in time of freshets might be accidentally carried over the dam.

This plan requires the raising of Enfield bridge, or a draw, which would oblige all boats to pass at one place near the west end of the bridge at ordinary high water.

The proposed modification of this plan, by making one dam below the island in place of the two above mentioned, would not materially change its character. It would have the benefit of shortening the canal to 1.64 miles, but would flow back on the west side of the island so as to interfere with the water-power on Stony Brook, before mentioned.

The difference between these modifications is chiefly one of cost, if the lower dam is not carried so far down stream as to endanger the railroad-bridge.

The first modification has some advantage over the second in the depth of water flowing over the dams in the highest freshets, which would be 10.1 feet for the first modification, and 11.8 feet for the second.

The fourth proposed plan of one dam near Enfield bridge, and another just below the railroad-bridge, can have the shortest canal of any of the proposed improvements, being 1.50 miles in length below the lower dam. This, however, would be more than compensated by the necessity of having one more lock.

This plan can have almost any width of canal desired without materially increasing the cost, but an increase of the proposed depth will make expensive rock-cutting at the upper dam.

It has the disadvantages consequent upon having two dams in the main channel of the river, with their insecurities and repairs, and the risk of boats going over them in freshets.

This plan also gives a less head of water at Warehouse Point by 11 feet, and has no favorable place for manufacturing-establishments along its banks.

The greatest disadvantage possessed by this plan, however, is the great depth of water on the upper dam in time of freshets. This would be 15.2 feet, and would dam the water back in the river above to a height of 3 feet more than is now the case, and would probably cause some damage above, not considered in the estimate.

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The lower dam, also, would have upon it, at high water, 12.4 feet, which is more than would be on the dams in the other plans.

The fifth proposed plan of improving the present canal has all the advantages of the canal on the east side of the river, without contracting the water-way above the island. It also has the advantage of drawing rents from manufactories already established, using water-power from the canal. It leaves the river-channel open like the other proposed canals, and it could draw all the water from above Enfield Dam, if desired, instead of only a part, as would be the case with either of the other proposed canals. It has the advantage, also, that it could be executed part at a time, as the necessities of navigation might require. The locks could be first constructed and the widening done afterward, as might be necessary for larger boats than those now used. Its principal disadvantages are the opposition that the plan would receive from the owners of property taken for the widening, and that it would be necessary to purchase the franchise of the Connecticut River Company, the shares of which would rise in value if it was known that the Government desired to purchase it.

The modification of this plan, by making only new locks at present, has only the advantage that if the size of boats hereafter used would not warrant it, the work need not be fully carried out, but only such a widening made as is requisite.

In this way the original expense would be less, and the final cost perhaps not greater than by either of the other plans.

PLANS SELECTED.

A careful consideration of the estimates of cost, with the advantages and disadvantages of each of the proposed plans of improvement, will, it is believed, cause the rejection of the first plan, the modification of the third plan, the fourth plan, and the fifth plan, leaving to be considered the second, third, and modified fifth plans; and to these preference is given in the order named.

The contraction of the water-way near Enfield bridge is the only serious objection to the second plan, and it is believed that a safe location of the canal can be made.

The low dam at the Enfield entrance, which would not be dangerous for boats if drawn over accidentally at high water, is deemed more than an offset to the short canal, and other advantages of the third plan, with its high dam at the entrance to the canal.

If the original outlay is to be limited to the smallest amount possible, with a view to future enlargements as necessity may require, the modified fifth plan is the one which should be selected.

FURTHER IMPROVEMENT OF THE RIVER.

Whatever plan for the improvement of the rapids may be adopted, it should be in view of further improvements between the foot of the rapids and the city of Hartford. The expense of making a channel of 6 or 7 feet deep will not be much greater than one of three or four, which is now the ordinary limit of depth in the channel below at the lowest stages of the river. The estimates, therefore, have been made with this in view.

The channel of the river can be so improved as to carry 7 feet of water up as far as Springfield, Massachusetts, if the amount of traffic would warrant it. In this case vessels navigating Long Island Sound, or even sea-going craft of moderate size, could proceed directly to Springfield, and save the transshipment now necessary at Hartford.

All of which, with the accompanying list of maps, tables of approximate discharge, and list of bench-marks, is respectfully submitted.

THEO. G. ELLIS,
Civil Engineer.

Major-General G. K. WARREN,
Major, United States Engineers.

LIST OF MAPS.

Accompanying this report is a map of Enfield Rapids, on a scale of 400 feet to an inch, or $\frac{1}{4800}$, showing the several plans of improvement. Also a sheet showing sections across the river, numbered on the maps from 0 to 55.

To show the river above and below the rapids, reference is made to the map of the Connecticut River from Hartford, Connecticut, to Hadley, Massachusetts, accompanying my report on proposed improvement above Hartford, of March 4, 1871. And to show the river from Hartford to Long Island Sound, reference is made to the map accompanying my report of survey of the Connecticut River below Hartford, of January 11, 1868.

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Table of approximate discharge of the Connecticut River at Enfield Rapids, in tenths of the height, from low to high water at any point.

Height.	Cubic feet per second.	Notes.
.0	4,000	Deduced from observations on slope of water and sections of bed between Hartford and Scantic, by Humphreys and Abbot formula.
.1	10,500	
.2	20,500	
.3	37,500	
.4	51,000	
.5	61,500	
.6	73,600	
.7	96,000	Interpolated.
.8	118,500	Interpolated.
.9	141,000	Interpolated.
1.0	162,000	From deepest water on Holyoke Dam, Rankine formula.

Bench-marks—Heights from 0 of Hartford gauge-board.

ON EAST SIDE OF RIVER.

Northeast corner of underpinning stone at northeast corner of red tobacco-shed, near section 3, 29.81 feet.

Nail in south one of two maple trees in front of white house, east of road, near section 9, 31.14 feet.

Top of southwest corner of abutment of railroad-bridge at Warehouse Point, 61.90 feet.

ON WEST SIDE OF RIVER.

Top of south one of two hooks in the top of east wall of south lock of old canal, 19.16 feet.

Top of southeast corner of abutment of railroad-bridge, near Windsor Locks, 62.02 feet.

Top of southeast corner of stone support to bridge over old canal, at north end of towpath, 51.20 feet.

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IMPROVEMENT OF NEW HAVEN HARBOR, CONNECTICUT.

The condition of this work at the close of the last working season was shown by my report, dated December 23, 1871, and by that of Mr. G. H. Mann, civil engineer, which accompanied it. For information to that date, I beg leave to append them to this report as a part of it.

During that season a channel of 13 feet deep at mean low water was dredged up to the city wharves; the amount of material excavated amounting to 153,718 cubic yards. A thorough survey of the harbor was made, and the shape of all the rocky reefs, forming obstructions, determined. The contractor (Mr. Eugene Sullivan) for removing Luddington Rock removed 127 cubic yards of it.

The time of his contract was extended this season. He commenced work again on the 14th of June, 1872, and has now about exhausted the appropriation under which his contract was made, having removed, this season, at the date of August 31, 422 cubic yards. This leaves about 275 cubic yards, according to last year's calculation, yet to be removed. Another survey will be made to test this.

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Congress, by the act approved June 10, 1872, appropriated $15,000 for continuing the removal of the rocks, and $20,000 for general improvement. Proposals for doing the work under this appropriation were advertised for, according to the following specifications:

REDUCTION OF LUDDINGTON ROCK.

After the former appropriation is expended, there will remain about 300 cubic yards to reduce it to 17 feet below mean low water.

REDUCTION OF BIG-BOIL ROCK.

There are about 587 cubic yards to remove to make a depth of 17 feet on it at mean low water. There is now a mean low-water depth of 7 feet on it.

Proposals for doing the above work will state the price per cubic yard, as measured on the deck of the vessel. No allowance will be made for rock taken from a greater depth than 17 feet below mean low water.

DREDGING.

A cut is to be made across the sand-bar, opposite Fort Hale, to increase the depth from 13 feet to 15 feet at mean low water. About $15,000 will be set aside for this work. The distance to be dredged over is about 3,000 feet. The scows must be dumped outside of Southwest Ledge, a distance of two to three miles.

Proposals will state the price per cubic yard, measured in the scows.

RIPRAP GRANITE.

Proposals will be received for about $4,000 worth of riprap granite, to be placed in a jettee on the south side of Fort Hale, from the high-water line seaward. The section of the jettee is to be a triangle, sloping 1 to 1 on each side. The stones should be in no direction less than one-third of the longest dimension, and may be any size from a cubic foot upward.

Proposals will state the price per ton.

The mean rise of the tide at New Haven is 5.8 feet.

The following is an abstract of the proposals received:

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Abstract of proposals for the improvement of New Haven Harbor, Conn., received at the engineer office, United States Army, Newport, Rhode Island, July 30, 1872.

Name and address of bidders.	Price per cubic yard for removing Luddington Rock.	Price per cubic yard for removing Big Boil Rock.	Price per cubic yard for dredging.	Price per ton for rip-rap granite.	Commence.	Complete.	Amount set apart ($4,000) for building jetties at price named, would produce—	Balance of appropriation used in dredging, at price named, would remove—	Amount appropriated would remove submerged rocks to the amount of—	Remarks.
			Cents.				*Tons.*	*Cubic yds.*	*Cubic yds.*	
Eugene Sullivan, New Haven, Connecticut.	$45 00	$45 00	.....	.....	Aug. 10, 1872	June 30, 1873	.....	.....	333⅓	Signatures of guarantors not witnessed; guarantee not dated.
S. F. Shortland & Brother, 106 Wall street, New York City.	.....	.....	19. 73	.....	Aug. 15, 1872	As soon as practicable.	.....	81, 094	.....	No certificate that guarantors are responsible parties.
Francis H. Smith, 121 Front street, New York City.	.....	.....	20. 94	$2 19	Aug. 15, 1872	June 30, 1873	1, 826	76, 408	.....	Bids for 1,500 tons of granite.
R. G. Packard & Co., 361 Fulton street, Brooklyn, Long Island.	.....	.....	21	.....	Sept. 20, 1872	June 30, 1873	.....	76, 190	.....	In case our bid for dredging in Huntington Harbor, Long Island, N. Y., is accepted, we will commence on the work at either place, as directed, on or before the 20th day of September, 1872, and push it forward as rapidly as possible, in which case we will commence the deferred or second job at the time of completion of the first, pushing it forward as rapidly as possible, both to be completed on or before the 30th day of June, 1873.
Sidney F. Shelbourne, 11 Gold street, New York City.	.....	.....	21. 49	.....	When direct'd	June 30, 1873	.....	74, 453	.....	
Morris & Cummings, New York City ..	.....	.....	27	.....	Aug. 15, 1872	Nov. 1, 1872	.....	59, 259	.....	
D. V. Howell, 141 Chambers street, New York City.	.....	.....	.....	2 28	Sept. 1, 1872	June 30, 1873	1, 755	.....	.....	Guarantee not dated.
John Beattie, Stony Creek, Connecticut.	.....	.....	.....	2 70	Aug. 10, 1872	Mar. 10, 1873	1, 481	.....	.....	Signatures of guarantors not witnessed.
Dawson, Tank & Co., New London, Conn.	.....	.....	.....	2 70	Sept. 1, 1872	June 30, 1873	1, 481	.....	.....	
John S. Steedwell, New York City.....	.....	.....	.....	2 90	Sept. 1, 1872	Last of June, 1873.	1, 379	.....	.....	Signatures of guarantors not witnessed, and no certificate that the guarantors are responsible parties.
Andrew W. McKee, Huntington, Long Island, New York.	.....	.....	.....	3 25	Aug. 20, 1872	June 30, 1873	1, 230	.....	.....	Proposals for Bridgeport, New Haven, and Port Jefferson made out on one blank.
C. W. Campbell & Co., Lyme, Conn....	.....	.....	.....	4 00	Aug. 15, 1872	June 30, 1873	1, 000	.....	.....	

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The lowest bid for furnishing stone for the jettee was $2.19 per ton by Mr. Francis H. Smith, of New York. It is now probable, however, that no stone will be needed for this purpose, at present.

The lowest proposal for the dredging was made by Messrs. S. F. Shortland & Brother, of New York, which was for 19.73 cents per cubic yard. A contract has been made with them, and they commenced work in August.

Mr. Eugene Sullivan made the only proposal for removing the rock-reefs, and this was $45 per cubic yard. This was considered too high, his previous contract having been at the rate of $25 per cubic yard, and the proposal was rejected. I now believe it is better to advertise for the complete removal of Luddington Rock down to the required depth in a lump, and not by the cubic yard, as heretofore. I propose to advertise for proposals to do this as soon as the new measurements are made. This work has been superintended by Mr. G. H. Mann, civil engineer.

For continuing the work of dredging and removing rocks, during the fiscal year ending June 30, 1874, I recommend an appropriation of $25,000.

New Haven is a port of entry, and is in the collection-district of the same name. The amount of revenue collected here in the fiscal year ending June 30, 1872, was $222,065.36.

Statement of funds.

Amount available July 1, 1871	$44,753 87
Amount appropriated by act June 10, 1872	35,000 00
Amount expended during the fiscal year ending June 30, 1872	35,726 63
Amount available July 1, 1872	44,027 24
Amount required for fiscal year ending June 30, 1874	25,000 00

ENGINEER OFFICE UNITED STATES ARMY,
Newport, Rhode Island, December 23, 1871.

GENERAL: I have the honor to submit a report on the operations of improving the harbor of New Haven, Connecticut, during the season just closed.

The condition of these works at the date of my annual report, August 31, is given in your printed annual report of this year, pp. 85 and 768, 769, 770, 771. At that time a large part of the necessary surveys had been made and contracts entered into for removing the rocky ledges at the entrance and for dredging from Black Buoy No. 5 up to the city wharves. As then stated, the contractors were at their work and making satisfactory progress.

Morris & Cummings, the contractors for the dredging, commenced work on the 10th of July and completed their contract on the 31st of October. During this time they dredged from the channel and removed outside of the harbor 153,718 cubic yards of material, mostly a clayey mud. In my previous report I stated there were but 7½ feet in the channel at mean low water, but this was a mistake; there were about 9 feet at mean low water. The new channel was excavated so as to make 13 feet depth at mean low water, which is the depth on the bar opposite Fort Hale, and thus vessels of any draught that could cross this bar can proceed directly to the wharves without lightering.

The dredged channel is 200 feet wide from the 13-foot curve up to Long Wharf, a distance of 3,125 feet. There the channel makes a bend, and was widened to 350 feet up to the canal-dock, a distance of 750 feet; thence to the steamboat-dock, a distance of 2,125 feet, the channel was made 100 feet wide. The wharf-owners have since begun to dredge around their piers, thus still further adding facilities to commerce.

In my previous report I stated that I considered no more dredging was necessary, and I would now qualify it by saying no more in this part of the harbor. But there is a great demand for an increase of depth over the bar at Fort Hale, so that vessels of heavy draught arriving there may not have to wait for the tide in order to pass at once into the inner harbor. Once inside of this bar there is deep water and excellent anchorage, which latter feature is wanting outside of the bar. Many persons think that simple dredging is all that is required to secure this increased depth on the bar, which

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is composed of fine sand and has remained unchanged since the earliest surveys were made. I cannot agree with those who think so, as I believe there is an almost constant movement of this sand westward, across the mouth of the harbor, and that the present depth is merely the result of an equilibrium of the action of the waves on the one hand in moving the sand toward the shore, and the action of the tidal current on the other, sweeping it out again. If this equilibrium is disturbed by dredging a channel the cut will be filled again in the same way as the drifting snows fill up a railroad-cut. But there is this difference, that in excavating the channel we may increase the force of the tidal currents so that the cut will be kept open, and this, it is claimed, will be the case by those advocating the dredging. There is enough reason in this to give dredging a trial, and it is the more justifiable as there does not seem to be any other more promising method to pursue.

The distance between the curves of 16 feet depth at mean low water on the outside and inside of this bar or shoal is about 5,000 feet, and it will require an average cut 2 feet in depth to give a draught of 16 feet over it. It is estimated that a channel 200 feet wide would require the removal of about 75,000 cubic yards, at a cost of 35 cents per cubic yard, amounting to $26,250. I have limited the depth to 16 feet at mean low water, as that will afford nearly all the benefit now wanted, and to get a greater depth would require a very large amount of money.

It may be that jettees along the shore to arrest the motion of the sand may be of service in keeping open the dredged channel, and this will be considered in the future prosecution of the work. The channel already dredged between Black Buoy No. 5 and the wharves is in no danger of silting up again.

Mr. Sullivan, the contractor for removing the submerged ledges of rock, began work on the 1st of August on Luddington Rock, and continued at work until September 30, when he ceased, on account of the increased inclemency of the season. In the two months he removed 126.8 cubic yards. He will resume work at this rock as early next season as the weather will permit. There remain 695 cubic yards to be removed.

The complete survey of the rocks at the entrance, which we made the past season, enables us now to present a definite project for their removal; and this differs considerably from anything heretofore reported on this subject.

The work was originally begun in 1852 and 1853 by Mr. Maillefert on Middle Rock, because it was thought that it furnished a favorable case for trying his method of surface-blasts. This method, however, failed, and under the contract the experimenter received no pay. The appropriation of $6,000 remained nearly all unexpended until 1867, when Mr. Townsend was employed by the day to operate with his drill and ordinary blasts upon it. From some cause, Mr. Townsend reported much success, and he claimed to have removed so much of the rock as to make 14 feet of water upon it, while before there were but 10 feet. Misled by this account, I, in 1870, employed him to work again upon Middle Rock. I soon became dissatisfied with the progress he was making, and began to distrust the accuracy of the statement of the success he had before reported. A survey of the rock revealed the fact that there were still only 10 feet of water on the rock, the same as it was at first. This disagreeable result was confirmed by a thorough and careful survey made again this summer. I did not resume work upon it.

It has been recommended to remove not only Middle Rock, but the Southwest Ledge also, and the two rocks between them, called B and C by Captain Dutton, and we have carefully surveyed them all. The amount of rock to come away before there will be 17 feet at mean low water on all these ledges just referred to is: Middle Rock, 818 cubic yards; Rock B, 141 cubic yards; Rock C, 624 cubic yards; Southwest Ledge, 1,964 cubic yards; all together 3,548 cubic yards, which, at $25 per yard, would cost $88,700. The distance from the Southwest Ledge to Middle Rock is 1,020 feet. It is thought by many that the entrance to the harbor would be benefited by erecting a light-house on the Southwest Ledge, which has 7¼ feet of water on it at mean low water. In that case it is thought that Middle Rock, and the intermediate shoal points B and C, need not be removed.

The principal entrance to New Haven is not on the side of the Southwest Ledge (east side) on which Middle Rock stands, but on the west side, and in the midst of this west channel stands Luddington Rock, with a depth on it at mean low water of about 10 feet. Vessels beating out and in the harbor pass on both sides of it, and it is very much in the way. I therefore directed work to be begun upon it.

In the channel east of the Southwest Ledge there is, however, a dangerous rock, first located by our survey, but known by the fishermen as the Big Boil. This rock has but 7 feet on it at mean low water, and should be removed. The amount of rock above the 17-foot curve is about 587 cubic yards, which, at $25 per yard, would cost $14,675.

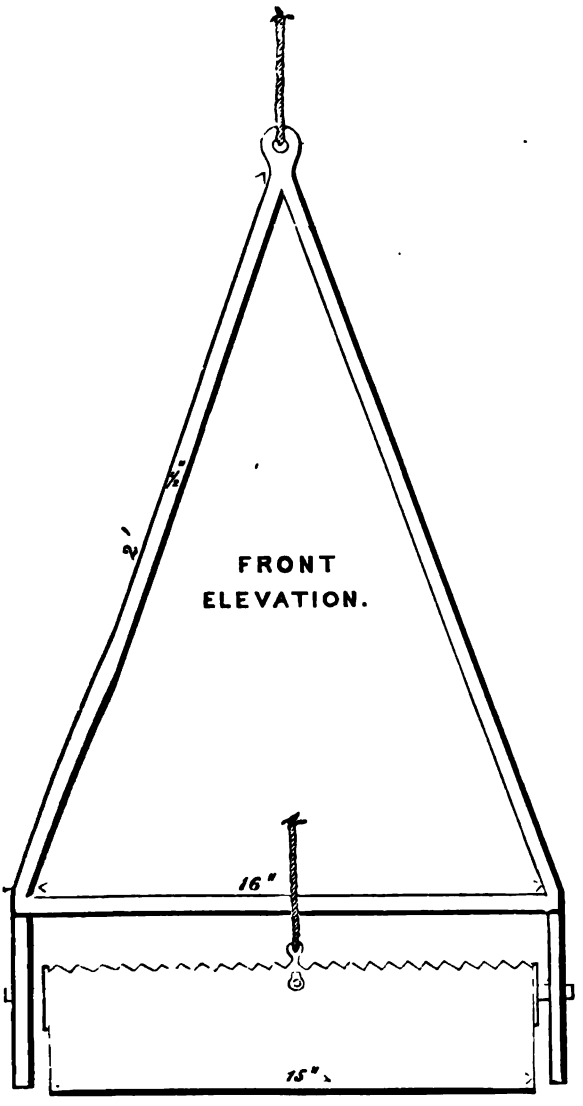
To finish the work in the harbor, which I think it advisable to do at the present time, (besides the light-house for Southwest Ledge,) will require as follows:

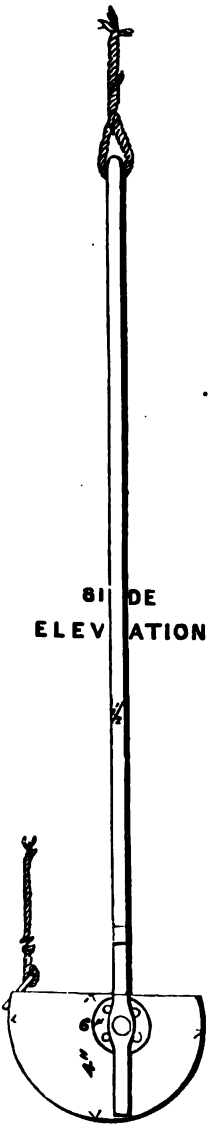
To complete the removal of Luddington Rock, 695 cubic yards, at $25 per yard	$17,375 00
To remove Big Boil Rock, 587 cubic yards, at $25	14,675 00

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DRAG *for* NEW-HAVEN HARBOR.

Scale: 2" = 1'.

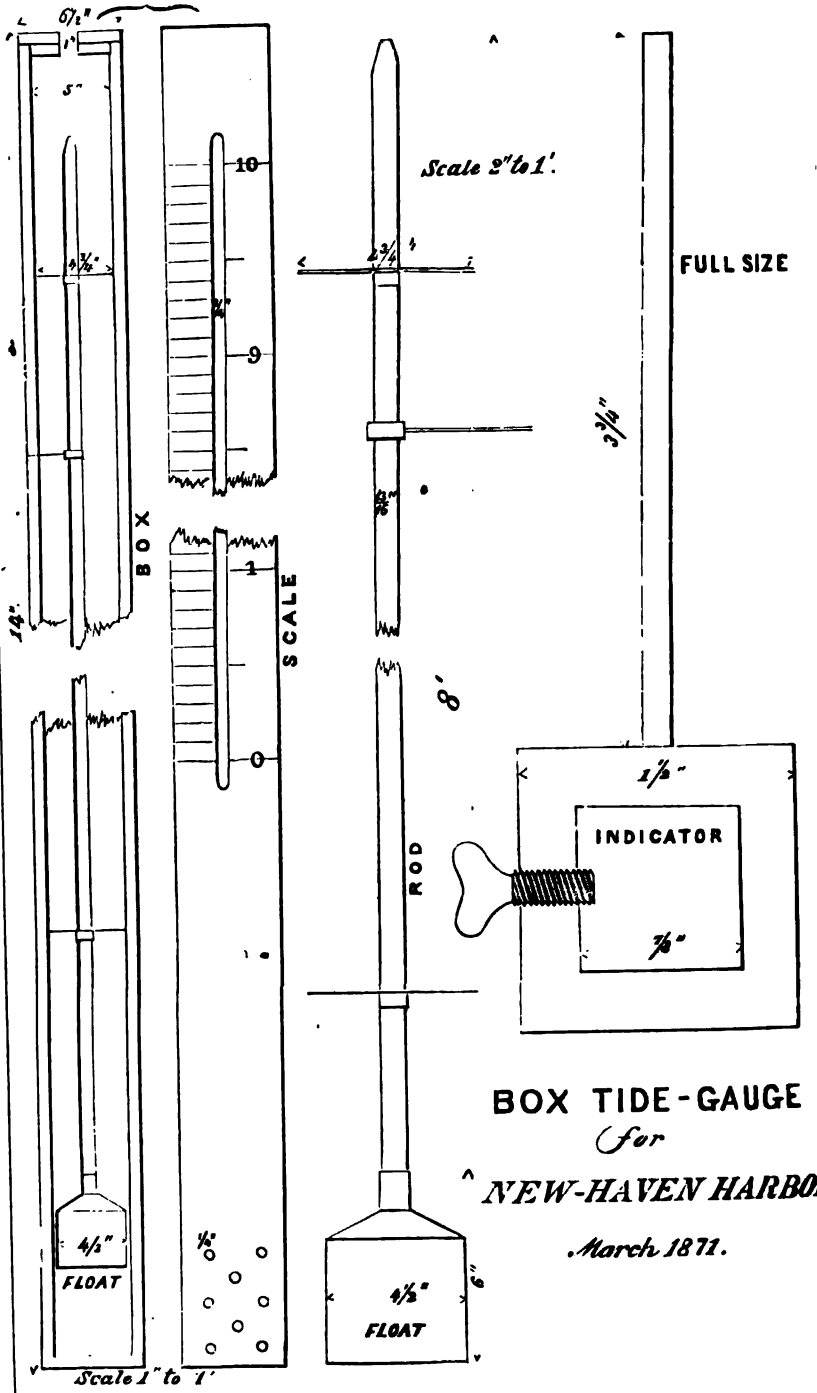




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BOX TIDE-GAUGE

for

NEW-HAVEN HARBOR

March 1871.

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To dredge a channel 200 feet wide, to a depth of 16 feet across the shoal near Fort Hale, 75,000 cubic yards, at 35 cents	$26,250 00
For superintendence	3,700 00
Total	62,000 00

During the past year the expenditures have been as follows:

For surveys, making maps, and superintendence	$7,218 43
To Morris & Cummings, for dredging	26,150 33
To Eugene Sullivan, for work on Luddington Rock	3,107 36
Total	36,476 12

The amount appropriated by the act approved March 3, 1871, was	$40,000 00
On hand at the beginning of the year of former appropriation	9,093 04
Total	49,093 04

Leaving the balance of the last appropriation still unexpended, $12,616 92.

It therefore appears that the additional appropriation required will be about $50,000.

In my annual report I recommended an additional appropriation of $20,000 for the ensuing year, but this was made without taking into consideration the improvement of the depth on the shoal near Fort Hale.

Accompanying this report is a tracing from the unfinished map of the new survey, showing the dredging done during the past season; also a tracing showing the correct locations of the rocky ledges at the entrance to the harbor; also six tracings showing the contours of these rocks, and one sheet of sections of Luddington Rock. Also a report of Mr. Mann, who has had charge of the survey and superintendence of the improvement, which contains much information not given in my report, and is a valuable record for future reference. The map of the harbor is being prepared, and is in an advanced stage.

Mr. Mann has been assisted all the time by Mr. C. R. Mather, and part of the time by Mr. H. N. Babcock. The energy, thoroughness, and completeness of the work commend these young men to all interested in their professional pursuits, and who desire to see a faithful execution of a public trust.

Very respectfully, your obedient servant,

G. K. WARREN,
Major of Engineers, and Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, December 23, 1871.

GENERAL: I have the honor to submit report of operations at New Haven Harbor Connecticut, during the present year. In accordance with your instructions, I left Newport on March 16, accompanied by Mr. Charles R. Mather, civil engineer. Operations were commenced on March 17 by the locating of tide-gauges at Long Wharf and Chapel Street Bridge, the gauge at Chapel Street Bridge being placed on the east side of the guard-piling of the draw-pier of the bridge; the gauge at Long Wharf being placed in a corner between the freight-house at the end of the dock and the east end of the dock. Simultaneous tide observations were commenced at these points on March 18, being taken every ten minutes between high and low water, and every five minutes for thirty minutes before and after high and low water. These gauges were observed until March 31, when simultaneous observations were commenced at Chapel Street Bridge, Long Wharf, Fort Hale, and Five-Mile Point. Tables of these observations are annexed to this report. At Long Wharf, Fort Hale, and Five-Mile Point box-gauges of the form shown in the annexed diagram were put up, this being rendered necessary by the prevalence of southwest winds which make the water too rough for accurate reading upon a staff-gauge. The tide-gauge at Fort Hale was placed on the east side of the chemical works docks, and that at Five-Mile Point on the north side of a dock belonging to W. H. Clark, esq. Observations were taken at all four gauges until April 15. On the 14th, 15th, and 17th, levels were run to connect the planes of reference as marked on the different gauges, and bench-marks put in as follows:

Bench-mark 1 consists of a copper bolt 6 inches long, ¾ inch diameter, and 1½ inches across, the head leaded into a large circular stone on the southeast corner of a passage-

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way through the west end of Long Wharf, about 60 feet east of P. P. Avery's store. The stone is level with the roadway, the bench-mark being in the south side of the upper face. The head of the bolt is 10.233 feet above the plane of mean low water as determined at the tide-station at Long Wharf.

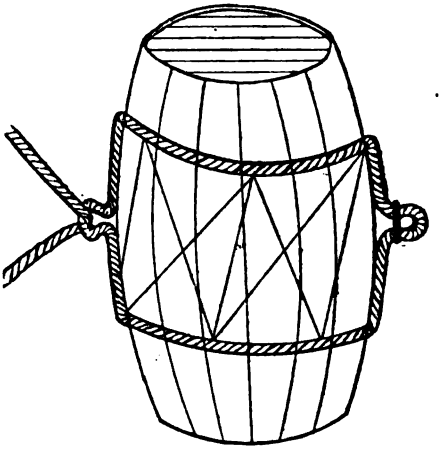
Bench-mark 2 consists of a copper bolt leaded in the northwest corner of the upper face of the northwest stone in the second course from the top of the east abutment of the draw-span of the Chapel Street Bridge; the stone forms a projecting corner, the bench-mark being inserted about 5 inches from its northwest corner on a line running southeast. The bench-mark is 9.631 feet above plane of mean low water as determined at the tide-station at Chapel Street Bridge.

Bench-mark 3 is a copper bolt leaded in the upper face, at the southwest corner, of the west stone of the north side of the sluice-way at the southwest corner of Fort Hale, and on a running line northeast from corner of said stone. The bench-mark is 11.919, feet above the plane of mean low water as determined at the tidal station at Fort Hale, (at chemical works dock.)

Bench-mark 4 is a copper bolt leaded into the second stone from the north edge of the southwest face of the water-table of the New Haven light-house; the bolt is about 4 inches from the upper edge of the stone, the head being flush with its face and notched thus, ⊕. The horizontal notch is 20.866 feet above the plane of mean low water, as determined at the tidal station on dock belonging to W. H. Clark, esq. At the two last stations, as the observations extended over only half a lunation, mean low water was determined by subtracting one-half of the mean rise and fall of the tide, (spring, the observations extending over a period of high tides,) taken from United States Coast-Survey records from the height of the mean sea-level. At the other stations the mean of the low waters for a lunation determined the plane of mean low water. I also found that the tide-gauge used during the survey of Middle Rock in 1870 was put up by Mr. R. M. Bache, of the United States Coast Survey, and observed for a month, and that his mean low water, as used by me in 1870, differed but 0.05 feet from that of 1871. On April 19 I examined the channel below Long Wharf, with the dredge shown in the diagram, for the purpose of determining the character of the bottom and the depth at mean low water. I found that the bottom consisted of soft mud, mixed occasionally with broken shells, but in no place was anything struck approaching the consistency of hard mud. Soundings commencing at Long Wharf and extending to 14-foot curve, near Black Buoy No. 5, gave a mean depth of 9 feet at mean low water. No oyster-beds were struck, nor any considerable accumulation of shells, and the statements of pilots in regard to the existence of any well-defined bar between Long Wharf and Black Buoy No. 5 were conclusively shown to be erroneous. On the 17th, 18th, 19th, and 20th of April, primary triangulation stations, consisting of poles 25 feet long and 2 by 3 inches, having large red flags at top, and supporting tripods, were erected at the following prominent points in the harbor below the bridge: A, near east end of Tomlinson's Bridge; A′, on Belle Dock; B, opposite Long Wharf on east shore; B′, on end of Long Wharf; C, at Fort Hale; C′, on Oyster Point; D, at light-house; D′, on Sandy Point; E, on Brister's Hill, on west side of harbor, back of Savin Rock. The base line A B was also measured and found to be 2,396.5 feet in length. On the 21st, 22d, and 24th, the angles of the primary trangulation were measured by the Troughton & Simms theodolite, reading to 10″, each angle being taken three times. The variation of the sum of the angles of any triangle from 180° in no case exceeded 25″. These angles have been corrected by ordinary method, founded on method of least squares, and the sides of the triangles computed. The traversing of the shore line was commenced on April 25, at north end of base, and was completed on May 6, being run to the light-house on the east shore, and to a point just below Savin Rock, on the west shore, and connected at every principal station with the primary triangulation. A limited topographical survey was made in connection with the traversing by Mr. Charles R. Mather, civil engineer. The total distance traversed was 52,000 feet; the stations were marked as follows: 1 A, 2 A, &c., running south from north end of base 1 B, 2 B, &c., from same point north and west. On May 8 a survey of the openings of the sea-wall at Fort Hale was made to determine the amount of repairs required. On May 9 preparations were made to commence sounding, and on the 10th it was begun at Tomlinson's Bridge, and concluded on May 20, extending to a point opposite the middle of Morris's Cove. About 2,600 soundings were located by two transits, the lines being run zigzag and taken so as to determine changes of level, the pole used in less than 20 feet of water being kept on the bottom most of the time. A system of signaling by red and white flags was adopted, and the numbers of soundings checked at the end of each line; in case of soundings being lost by instrument, which was very rarely, the line was rerun. While sounding, the gauge at Long Wharf was read every 15 minutes, and the soundings reduced to mean low water by these observations, the time being taken in the boat every 5 minutes. Several lines of soundings were located, radiating from Long Wharf, so as to determine the axis of the channel, which was found to coincide very nearly with a line from Long Wharf to Black Buoy No. 5. The soundings were completed to the entrance of the harbor in the Fall. This

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will be referred to in its proper chronological order. On May 22, 23, 24, and 25, buoys, ropes, &c., for the surveys of the rocks at the entrance to the harbor were prepared and taken out to Middle Rock and placed in position for the survey of that rock. On the 27th a complete survey of Middle Rock was made, including those parts necessarily omitted in 1870, in the following manner: Four kerosene-oil barrels were strapped, as shown in the diagram, and provided with two 100-foot anchor-warps each. These buoys were arranged in the form of a square, as in the diagram, (see next page,) and were connected by rope 150 feet long, passing through and fastened to an eye formed of the bight of the rope on the barrel inclosing an iron thimble. These ropes were marked at every 5 feet by strips of red bunting inserted between the strands. The angles of the square were laid off with a sextant, and the buoys held in place by anchors, and also by being strung up to the four spar-buoys left after operations in 1870, so that any displacement was impossible. The survey was made about the time of slack water, as nothing could be done at the strength of the tide. The survey was commenced at the northeast end of the rock, the north side of the square being taken as the base from which all the lines were run, the bearing of the base being south 80° east, (mag.) Soundings were taken at every 5 feet along the lines running north and south, the sections being 10 feet apart. During the survey the gauge at Five-Mile Point was read, the soundings, 370 in number, being reduced to mean low water by these observations. The soundings were taken with a pole 31 feet long, having feet and half feet branded upon it, as I have found that a painted pole is of little use in salt water. The lower end of the pole consisted of an iron rod 6 feet long and ¾ inch diameter, fastened thus: By keeping this constantly on the bottom no prominent inequality can escape notice. I also sounded thoroughly around the rock, to ascertain if I had been mistaken in stating that there was no broken rock left there in 1867 by Mr. G. W. Townsend, but found that my former statement was entirely correct. A map of Middle Rock has been made on a scale of 5 feet to the inch, the contours being drawn at every foot, 12 and 18 foot contours heavy, and the line of proposed excavation (17 feet below mean low water) in blue. The map is different in some minor respects from those made from the survey of 1870, but is more correct, as in 1870 the water was very rough, while in 1871 it was almost a dead calm during the entire survey. I find the least depth of water on the rock to be 10.4 feet at mean low water in 1871, and 10.0 in 1870. This difference is undoubtedly due to the difficulty of taking exact soundings in 1870. The survey of 1871 included that portion of the rock lying to the south, which was omitted in 1870. I give a comparison of the areas of the curves (below plane of mean low water) from the two surveys, these areas being completed by reducing the curves to equivalent triangles and measuring their bases and altitudes. The difference of the areas of the lower corresponding curves results from the introduction of the south part of the rock, which is quite flat, and which did not appear in the survey of 1870, but is entirely included in that of 1871.



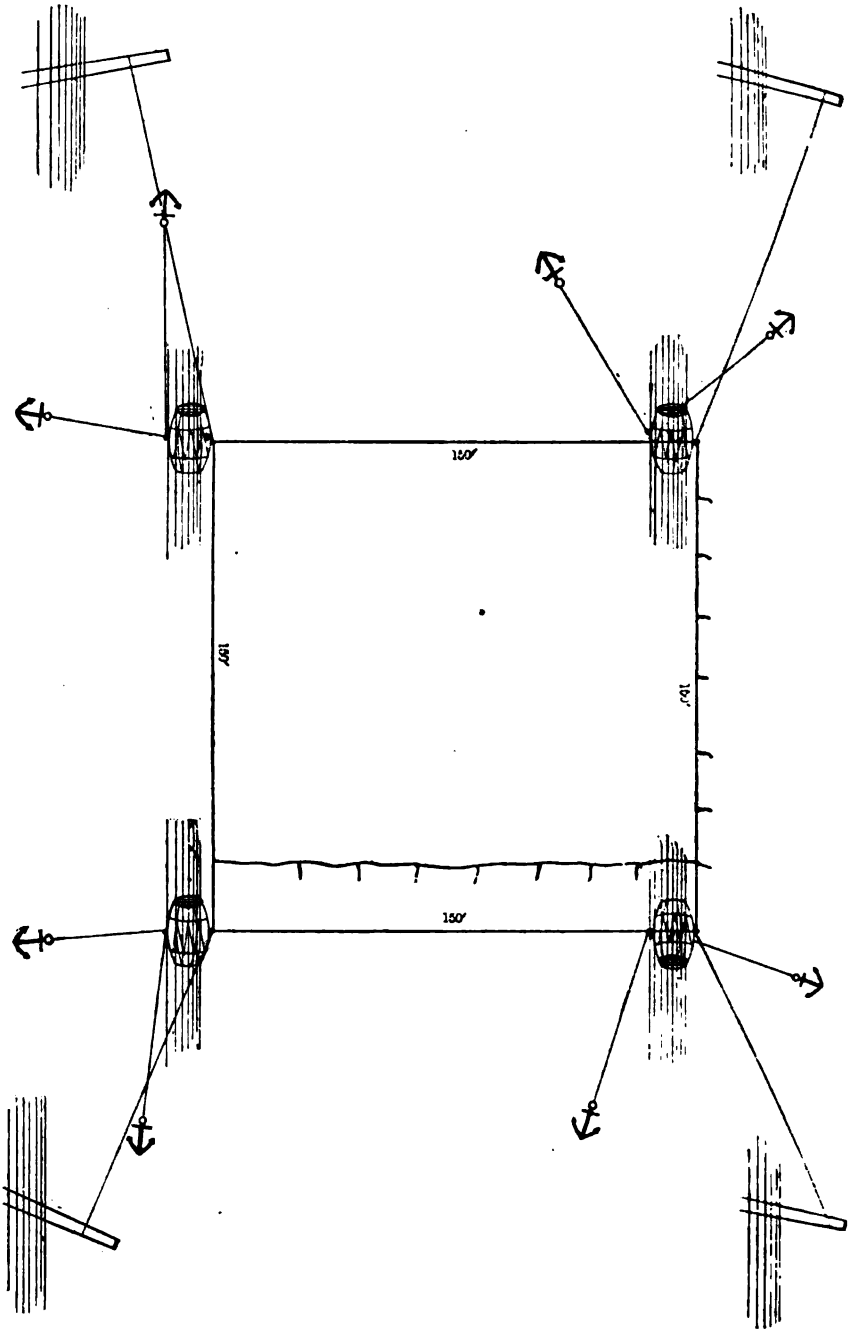


Area.

Curve.	1870.	1871.
Feet.	*Square feet.*	*Square feet.*
11	358.88	273.64
12	1,282.66	1,168.11
13	2,243.5	2,468.062
14	3,315.5	3,826.827
15	3,647.5	4,930.900
16	4,894.0	5,851.552
17	6,036.89	6,804.9125

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The volume has been computed by two methods: 1st. From horizontal sections at every foot of vertical height, (the areas being given above,) by the prismoidal formula.



For instance, assuming 11 and 13 foot curves as upper and lower bases and 12 foot as middle base, there result the volumes between the 11 and 13 foot curves, thus:

$$\text{Vol.} = \frac{2}{6}\left\{(11) \;\&\; 4\,(12) + (13)\right\}$$

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and in like manner for the other curves. I find by this method for the volume above the 17-foot curve 809.32; par. 2d. By vertical sections whose areas are determined directly from the reduced soundings, by the opplication of Simpson's rule, thus: subtract each reduced sounding from 17 feet, then the area of each vertical section will be as follows:

$$\text{Area} = \frac{\text{Distance between soundings}}{3} (\text{1st height \& } 4 \times \text{even heights} + 2 \times \text{odd heights} + \text{last height})$$

In this way I find for the areas at the following distance from east end of base:

Section. *Feet.*	Area. *Sq. feet.*	Section. *Feet.*	Area. *Sq. feet.*
15	0.	70	316.8
20	76.6	80	319.3
30	225.2	90	204.6
40	241.3	100	115.2
50	364.2	110	12.8
60	371.6	115	0.

The volume was then computed from these areas by the prismoidal formula and found to be 826.6 cubic yards. The most probable volume of the rock is then the mean of these results, or 817.96 cubic yards above the 17-foot curve, (below mean low water.) Comparing this with the result of the survey in 1871, and with that computed from Captain Dutton's areas from his survey in 1853, I have the following volumes:

	Cubic yards.
1853	768.36
1870	728.38
1871	817.96

The discrepancy may seem large, but the greater accuracy of this year's survey, and the more favorable conditions under which it was made, would lead me to adopt the volume deduced from it in any subsequent estimates, more especially as the volume given in Captain Dutton's report, as deduced from his areas, was really double the amount actually corresponding to the area, which of course does not tend to strengthen faith in the correctness of the areas themselves. The depth of water on the sand about Middle Rock is 22.5 feet at mean low water on the north side and 23.6 feet on the south side. The survey in 1870 gave 22.3 and 23.3, this being additional proof of the general accuracy of the depths taken then, and further proof, if any be needed, that Mr. Townsend's plane of low water when 15 feet was found by him on the shoalest point of the rock must have had its origin in his imagination. All the rocks at the entrance to the harbor appear to have deeper water on the south than on the north side, probably due to their checking the silt, &c., brought down by the strong ebb-tide. During the week ending June 3 several attempts were made to survey Southwest Ledge, but without success, as southwest winds made it too rough for work. A heavy fog each day prevented other out-door work. On June 5 I surveyed Southwest Ledge by the checker-board method, the barrels being arranged as follows: The base, 365 feet long, and bearing north 33° east, made an angle with the side of the parallelogram of 85°, the side being 200 feet in length. The angles were measured with a sextant. The base and the side parallel were marked at the 10-foot points by red bunting tags, and a line marked at every 10 feet was stretched from one to the other and moved along 10 feet at a time, so that soundings were taken at the corners of parallelograms 10 feet by 10 feet. The buoys were placed at slack water, and so arranged that the ebb tide ran in the direction of the lines of soundings. Each buoy was held by two anchors with long warps hauled taut, so that no swaying was possible during the ebb. A boat was anchored at the middle of the base to prevent swaying and sagging. The soundings were taken by allowing the boat to drop down with the tide along the line stretched from the base to the side parallel with it. After crossing it (the parallel side) the line was secured to it and soundings taken as before. During the survey the gauge at Five-Mile Point was read, and the soundings reduced to mean low water from the observations. About 450 soundings were taken. When the survey was nearly completed it commenced to blow from the south-southeast, so that the last two lines of soundings were taken 20 feet apart. During the survey the spindle-socket which formerly held a large spindle was struck and located; it is about 1 foot across, and has over it at extreme low water not more than 3 feet of water; it should be removed, or the spindle replaced, as it is very dangerous to light-draught vessels. A map of Southwest Ledge has been made to a scale of 10 feet to the inch, contours drawn at every foot of vertical height, the same colors being adopted for the curves as in the map of Middle Rock. The least water over the ledge at mean low water is 7.5. This is $\frac{1}{10}$ foot more water than is shown on the United States Coast-Survey chart. The ledge is about 310 by 250 feet, the longer

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direction being northwest and southeast; it is very jagged, being full of crevices. I have computed the volume by vertical and horizontal sections, as in Middle Rock. By vertical sections I have taken sections at noted distances from north end of base. By Simpson's rule:

Section. *Feet.*	Area. *Sq. feet.*	Section. *Feet.*	Area. *Sq. feet.*
97	.0	190	592.6
100	2.0	200	502.6
110	37.9	210	485.6
120	92.8	220	304.7
130	165.0	230	277.0
140	336.8	240	219.4
150	473.6	250	143.5
160	514.0	260	58.3
170	518.9	270	29.6
180	635.9	280	1.0

Then by prismoidal formula for the volume above the 17-foot curve (below mean low water) is 1,997.36 cubic yards. By horizontal sections the following results are given for areas of curves below mean low water:

Curve. *Feet.*	Area. *Sq. feet.*	Curve. *Feet.*	Area. *Sq. feet.*
8	149.64	13	6,116.88
9	585.90	14	7,845.45
10	1,195.20	15	9,843.92
11	2,848.25	16	12,086.87
12	4,364.58	17	15,062.14

Then by prismoidal formula the volume = 1,931.44 cubic yards, or taking the mean of the two results, 1,964.40 cubic yards, for the volume of the ledge above the 17-foot curve, (below mean low water.) Until June 14 the time was occupied in dragging for the rock known as Luddington's Rock, the position of which was not marked by any buoy, and, as I afterward found, was incorrectly located on the United States Coast-Survey map. On the 14th I found Luddington's Rock, also two rocks between Southwest Ledge and Middle Rock, known as Tortoise and Ragged Rocks, B and C in Captain Dutton's report, and a rock not marked on any chart, known as the Big Boil, (named from the tide-rip over it at certain stages of the tide,) lying about one-fourth mile south-southwest of Quixe's Ledge spindle, and having over it about seven feet at mean low water. I found ranges for all these rocks, so that I could drop a lead on them without any previous soundings, and marked the Big Boil with a small barrel-buoy, as the tide ran so swiftly there that it was somewhat difficult to strike the shoalest water on it. I was somewhat surprised to find less than 10 feet at low water on Luddington's Rock, instead of 12.5 as shown on the charts. Big Boil Rock lies directly in the entrance to the eastern channel of the harbor, and is a very formidable obstruction; B and C have over them at mean low water about 13 and 11.5 feet respectively. Luddington's Rock is a large rock, at least 150 by 100 feet, instead of a small peaked rock, as I was informed last year by the harbor pilots. I also sounded on Old Head Reef, about half way between Quixe's Ledge and Adam's Fall, finding on it about 9 feet at low water; as the Coast-Survey map gives 6, I presume I did not strike the highest point. As it is not in the channel, I did not spend any more time on it, the only object being to know where it was. The following ranges were noted for Luddington's Rock: Quixe's Ledge spindle is on range with the south edge of the only large white house on the "South End;" the north edge of two brown cottages on the beach, just north of Savin Rock, is on range with the spire of the southernmost of the two churches in West Haven: these cottages being at the high water are readily distinguished, as they are the only ones so situated. The Big Boil is on range of Quixe's Ledge spindle with bluff at mouth of Morris Creek, and on the range of the end of the woods on Morgan's Point, with the west edge of white house behind them to the north.

On June 16 I surveyed Luddington's Rock by checker-board method, the base line being 225 feet long, and bearing north; the side lines were 200 feet long, and were inclined to the base at an angle of 61° 30′, this angle being taken with the sextant. The side lines were as nearly as possible in the direction of tidal current, so that the sounding-boat could drop down with it. The sections were 10 feet apart, sounding being taken every 5 feet along them, beginning at the northwest corner of the parallelogram, the sections running from northwest to southeast, while the axis of the rock was from northeast to southwest. The base was prevented from sagging by a boat anchored at its middle. Three hundred soundings were taken, being reduced to mean low water by observations at Five-Mile Point. A map has been made of Luddington's Rock, on a scale of 5 feet to 1 inch, contours 1 foot apart; 12-foot contour heavy:

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16-foot contour, line of proposed excavation. The rock is about 150 by 100 feet, the longer axis northeast and southwest. The rock is very jagged, rising in some places quite abruptly, and affords excellent opportunities for face or surface blasts. There is on the highest point 9.8 feet at mean low water, and on the surrounding sand 16 to 17 feet at mean low water. The rock consists of two portions, connected by a narrow ridge; this ridge is not shown on the map, as its existence was first discovered by the diver; I afterward examined it myself. and found it to be quite small.

Luddington's Rock is a much better locality to work in than Middle Rock, as the velocity of the tide is less, thus making it smoother in the southwest winds. The volume of the rock has been computed by horizontal and vertical sections as follows:

1. By horizontal sections:

Curves.	Area of larger part, sq. feet.	Area of small part, sq. feet.	Curves.	Area of larger part, sq. feet.	Area of small part, sq. feet.
10	14.30		14	5,113.10	182.00
11	527.56		15	6,842.76	551.49
12	1,424.80		16	8,147.72	1,260.32
13	2,944.80	8.021			

BY PRISMOIDAL FORMULA.

Volume of, (1)	cubic yards	760.609
Volume of, (2)	do	47.589
Total volume		808.198

2. By vertical sections, from north end of base:

Section.	Areas.	Section.	Areas.	Section.	Areas.
Feet.	*Sq. feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Sq. feet.*
0	11.2	55	125.3	115	305.8
5	1.2	65	168.9	125	214.9
10	11.0	75	223.0	135	230.1
15	17.9	85	255.8	145	138.6
25	43.5	95	255.1	155	64.7
35	71.7	105	305.5	165	21.7
45	121.1				

The areas being found by Simpson's rule, the distance between the sections taken perpendicular to them being $10 \times \sin. 61^{\circ} 30'$; then using prismoidal formula: Volume = 835.94 cubic yards; the mean of the two results being 822.069 cubic yards. There has also been made a map on a scale of 5 feet to the inch, showing vertical sections along lines of soundings of Luddington's Rock at a distances of 75, 85, 95, 105, 115, 125 feet from north end of base. In this map the blue line represents plane of mean low water; heavy red line, plane of proposed excavation; black figures show amount (depth) to be removed at given points, and red figures show reduced soundings at those points; in this map the sand gulley in the rock is shown. On June 19, Ragged Rock, or C, was surveyed by checker-board method. The base, bearing south 42° west, was 190 feet long. The sections were 10 feet apart and made an angle with the base of 118° 33′, soundings being taken at every 5 feet along these sections for a distance of 220 feet. The rock is very jagged, there being several ridges upon it not more than a foot across and rising 5 or 6 feet above the surrounding rock, and having over them from 11.5 to 13.5 feet at mean low water. The sounding-pole was kept upon the bottom between all the soundings, and the position and extent of any marked inequality thus determined. Captain Dutton could not have struck these ridges, as he gives the least depth on the rock at 13 feet. Soundings were taken on the southwest side only to the depth of 20 feet, on account of the approach of darkness. There have been made two maps of Ragged Rock, one on a scale of 5 feet to the inch; in this the contours are at every foot, 12 and 18 foot curves heavy; 17-foot curves, (line of proposed

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excavation,) in blue. The shoalest point on the rock is 11.4 feet below mean low water, at Five-Mile Point, to which plane of reference were reduced the 640 soundings taken on the rock. This rock is about 210 by 160 feet, the axis being from northwest to southeast, (at 20-foot curve.) From appearances it is much cracked and fissured. Another map has also been made on a scale of 2 feet to the inch; from this it will be seen that there are four ridges having over them at mean low water 12.6, 13.2, 12.5, and 13.5 feet, and that to remove them to 17 feet below mean low water (blue line) would require the removal of but little rock, while the main portion of the rock is quite extensive. The volume of the rock has been computed by both methods. By horizontal sections the following results have been obtained:

Curves. Feet.	Areas. Square feet.
12	138.55
13 Second ridge	1.9
13 Third ridge	2.5
13 Main curve	726.57
14 First ridge	1.9
14 Second ridge	3.9
14 Third ridge	10.7
14 Fourth ridge	1.1
14 Main curve	1,922.5
15 First ridge	12.7
15 Second ridge	8.1
15 Third ridge	17.
15 Fourth ridge	3.5
15 Main curve	4,372.32
16 First ridge	29.36
16 Second ridge	17.64
16 Third ridge	26.4
16 Fourth ridge	5.51
16 Main curve	5,465.17
17 Second ridge	27.4
17 Fourth ridge	7.75
17 Main curve	8,553.26

Then, by the prismoidal formula: Volume of that portion of the rock separate from the ridges=623 cubic yards. Volume of ridges=8.84 cubic yards, or total volume of rock above 17-foot curve (below mean low-water)=631.84 cubic yards.

By vertical sections, at noted distances from end of base, the following results have been obtained:

Sections. Feet.	Areas. Sq. feet.	Sections. Feet.	Areas. Sq. feet.
50	2.0	120	340.7
60	25.3	130	257.7
70	79.9	140	98.7
80	119.2	150	64
90	252.4	160	3.4
100	300.9	169	0.
110	320.0		

Areas by Simpson's rule; then by prismoidal formula. Volume above 17-foot curve 617 cubic yards, the mean of the two results giving for most probable volume of the rock above 17-foot curve, (below mean low water,) 624.42 cubic yards. On June 20, rock B, or Tortoise Rock, was surveyed. The base was 80 feet long, bearing north 20° east; the lines of sounding being inclined to it an angle of 61° 54′, and being 5 feet apart, running southeast to northwest, soundings 5 feet apart commencing at southeast end. The south side of the rock below the 17-foot curve was not obtained, in consequence of wind. As this is, however, quite uniform, the other contours were introduced without any difficulty. The rock is very smooth and rounded on the top. Three hundred and ninety soundings were taken and reduced to mean low water at Five-Mile Point. A map has been made of this rock on a scale of 5 feet to the inch, curves as in other rocks. The highest point on the rock is 12.9 feet below mean low water. The rock is about 100 by 60 feet, axis northwest and southeast. The computations for areas and volume give by the two methods the following result:

By horizontal sections—

Curves. Feet.	Areas. Sq. feet.	Curves. Feet.	Areas. Sq. feet.
13	2.632	16	1,544.62
14	199.47	17	2,706.56
15	787.695		

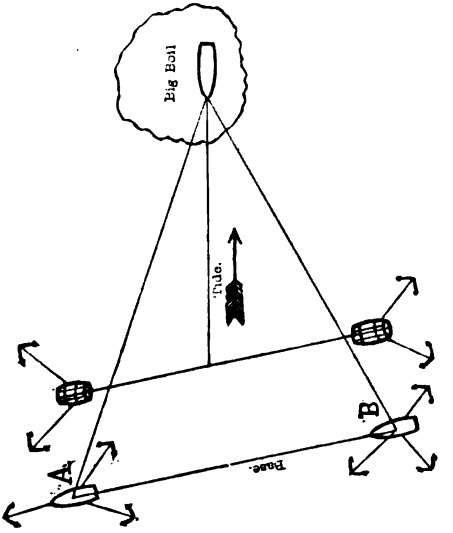
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Then by prismoidal formula volume = 138.99 cubic yards.

By vertical sections, the areas being found by the application of Simpson's rule, sections at noted distance from south end of base:

Sections. *Feet.*	Areas. *Sq. feet.*	Sections. *Feet.*	Areas. *Sq. feet.*
0	1.3	35	63.7
5	57.7	40	41.3
10	114.2	45	42.5
15	143.4	50	34.0
20	137.3	55	30.4
25	107.0	59	0.
30	101.6		

Then by prismoidal formula volume = 142.3 cubic yards, the mean volume above 17-foot curve (below mean low water) being 140.645 cubic yards. In order to preserve the connection, I will mention next the survey of the Big Boil, although it was not made until October 30, 1871. On the survey I was assisted by Mr. Charles R. Mather, civil engineer, and Mr. H. N. Babcock, civil engineer. The survey was made as shown in the diagram.



Boats were anchored at A and B, and their positions located by sextant angles between the following prominent objects: Light-house, and Quixe's Lodge spindle; light-house, and West Haven spire; these points being located on the principal survey as hereafter mentioned, the distances being calculated as well as the angles. From these data the length and bearing of the base have been calculated as follows: Length of base 482.2 feet, bearing south 22° 27′ 8″ east, (true.) Two barrels were anchored between the base and the rock, and connected by a line to which was attached another line to hold the sounding-boat in place while the soundings were being taken, this being necessary owing to the velocity of the tide. The soundings were then located from the ends of the base by sextant angles between sounding-boat and base. About 80 were taken and reduced to mean low water at Five-Mile Point. A map of this rock has been made on a scale of 5 feet to the inch, the soundings being platted from computed distances from the end of the base. The rock has 7 feet on it at mean low water, the dimensions at the 17-foot curve being about 110 by 80, the axis northeast and southeast. The areas and volumes of the rock by horizontal sections have been computed and are given. Curves below mean low water, 17 feet.

Curved plane of proposed excavation—

Curve. *Feet.*	Area. *Sq. Feet.*	Curve. *Feet.*	Area. *Sq. feet.*
8	47.73	13	1,313.13
9	231.58	14	2,171.59
10	486.11	15	3,004.42
11	714.12	16	4,175.88
12	971.35	17	5,539.63

Then, by prismoidal formula, volume above 17-foot curve, 586.71 cubic yards. On June 22, the rock at the entrance to the harbor, and the buoys in the harbor, were located by the theodolite. The shoalest point of each rock was located, the observer's stations being at the light-house station, (D,) and at the station on Brister's Hill, (E.) From this date until the dredging commenced, on July 10, the party was occupied in shipping Government property from Fort Hale, in measuring dredge-scows, and preparing for the dredging. Mr. Mather, as a mean of six observations, found the leaving of the base of the survey to be south 13° 58′ 55″ west, (mag.,) and, assisted by him, I ascertained, from a mean of seven observations, that the magnetic variation was 70° 22′ west. From July 10 until October 16 we were occupied by the dredging and removal of Luddington's Rock, Mr. Charles R. Mather, civil engineer, superin-

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tending the dredging. Mr. H. N. Babcock, civil engineer, joined us on July 26, and has been engaged principally in working up notes, mapping, &c. In accordance with your instructions I commenced, on July 26, a series of simultaneous observations at Long Wharf and Fort Hale, for the purpose of ascertaining whether the discrepancies shown in the following table were due to the irregularities of the tide, or to defects in the gauges employed. These observations were continued until August 9, and established the fact that the former peculiarities were due to the tide, not to the gauges. (Five-Mile Point agrees very well with Long Wharf.)

Date.	Height of high water.		Difference.
	Fort Hale.	Five-Mile Point.	
	Feet.	*Feet.*	*Feet.*
March 31	5.29	5.79	.50
April 1	5.49	5.94	.45
April 3	7.14	7.49	.35
April 4	6.54	7.19	.65
April 6	6.04	7.00	.96
April 7	5.84	6.80	.96
April 8	6.14	6.39	.25
April 9	6.74	6.59	.15
April 10	6.04	6.24	.30
April 11	6.74	6.69	.05
April 12	5.79	6.09	.20
April 13	5.84	6.09	.25
April 14	6.04	6.29	.25
April 15	6.14	6.49	.35

On October 16, in accordance with your instructions, I commenced a survey of the Mill and Quinnipiac Rivers, above Tomlinson's bridge, and extending to the Grand Street bridge on the Mill River and to the Fair Haven bridge on the Quinnipiac River, the limits of navigation on both rivers. Primary triangulation stations were located on the 16th, and the base line taken on Chapel Street bridge, its length being 914.5 feet, and bearing south 84° 56′ 02″ east, (mag.,) or north 87° 41′ 58″ east, (true.) On October 17 and 18 the angles of the primary triangulation were measured, each being read to 10″ three times on a different part of the plate. These angles have been corrected and the triangles computed. On October 19, a number of stations between Fort Hale and the light-house were replaced for use on the completion of the soundings to the entrance of the harbor. On October 21, about 100 soundings were located below the ending of the work in the spring; the gauge at Five-Mile Point was read, and the soundings reduced to mean low water at that point. From October 23 to 31, ran the shore-line of the Mill and Quinnipiac Rivers for a distance of 21,000 feet, a limited topographical survey being made in connection with the traversing by Mr. Charles R. Mather, civil engineer. On October 30 the Big Boil was surveyed, as before described. November 2, the soundings at entrance to the harbor were completed, about 185 soundings being taken, and reduced to mean low water at Five-Mile Point. November 3, the place beyond the rocks, at the entrance to the harbor, was surveyed in the manner described under the head of dredging, it having been used as a dumping-ground. On November 4 the survey of 1871 was connected with the United States Coast Survey, by observations with the theodolite, stations B and C of the primary triangulation being used, and sights taken to light-house, West Haven spire, and southwest spire of Episcopal church at corner of Olive and Chapel streets, New Haven. On November 8 commenced sounding Mill and Quinnipiac Rivers, locating soundings by two transits. This work was completed on November 16, 1,250 soundings having been taken, and reduced to mean low water at Chapel Street bridge. The channel dredged in 1871 was surveyed on November 17 and November 18. On November 27, operations being concluded for the year, Messrs. Babcock and Mather and myself returned to Newport. In addition to the maps already mentioned, there are prepared, or being prepared, the following: Map on a scale of $\frac{1}{2000}$, showing channel before and after dredging in 1871. (described under head of "Dredging;") map of the whole harbor, now preparing, on a scale of $\frac{1}{5000}$; sketch showing monthly progress of dredging. The following are to be made: Map of Mill and Quinnipiac Rivers, scale undetermined; map of dumping-ground, and comparison with United States Coast Survey map. The large map has the

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triangulation and traversing completed, the rocks located, and most of the soundings platted, so that the soundings yet remain to be completed, the shore-line and topography put in, and contours drawn. This will probably be done by January 20; until this time complete plans of the improvement of the bar below Fort Hale will have to be deferred, as there are so many circumstances affecting the deposition of sand in the sound harbors that any improvement of sand-bars in them can only be proposed after a careful investigation of the causes leading to their formation.

DREDGING.

From an examination of the channel made in the spring I determined, with your approval, to commence the dredging at the 13-foot curve, below mean low water, about 200 feet north of Black Buoy No. 5, and to make the west edge of the channel coincide with a line drawn from Black Buoy No. 5 to the end of Long Wharf. Morris & Cummings's dredge No. 2 arrived on July 3, and commenced making preparations for the work. At this time two scows, marked ○ and ⊕, were with the dredge. These were measured and found to contain 197.2 and 197.1 cubic yards respectively, and to draw about six feet when loaded. On July 10 the dredging was commenced at the point before determined, and as but little was to be taken off, the digging was done only at every other catch, the dredge making a cut fifty feet wide, and the bucket used holding three yards when flush with the top, and five yards when loaded up to the opening-wheel. For the first few days the progress was slow on account of the small number of scows, but on July 12 the tug Stephen Decatur arrived with two more scows, marked 1 and 2, and holding 202.5 and 199.4 cubic yards. Mr. Charles R. Mather, civil engineer, had previously been placed as superintendent of the dredging, in accordance with your instructions. The plan of dredging adopted was to run up on one cut until the back hawser, 700 feet in length, had been payed out; the dredge then dropped down to the point of beginning, and began another cut alongside of the former one, the average amount removed per day being about 1,600 yards, 2,400 yards being taken out on one day. The mud was dumped beyond Southwest Ledge, in 26 feet of water at low water, the locality being shown on the large map of the harbor. When a point about 1,000 feet from Black Buoy No. 5 was reached, it became necessary to dig at every catch, and sometimes to send the bucket down twice in the same place, the depth being regulated by tin figures placed upon the guide-poles of the buckets, and by board tide-gauges O at mean low water placed along at intervals as the work progressed. During July there were removed 23,697 cubic yards, about 2,100 feet of the first cut having been dug to 13 feet at mean low water, and about 1,400 of the second, and the same of the third to a corresponding depth. This progress is shown in red on the sketch, showing progress of excavation. Before commencing work on July 10 I sent the following notice to the New Haven papers: "The engineer in charge of the harbor improvements wishes to have the steamers 'slow up' when they pass the anchor-lines at the dredge, as the motion of the waves is injurious to the machinery, and the wheels of the steamers are apt to cut the lines. A channel is being dug 200 feet wide and 13 feet deep at low water from Black Buoy No. 5 to Long Wharf." I expected I should have no further trouble in regard to the matter, and was somewhat surprised when informed by Mr. Mather that no attention was paid to this request. I then went twice to the office of the company, and made verbal requests that the steamers "slow up," but without effect. We were put to considerable inconvenience, as sometimes half an hour was lost by the steamer passing at full speed, as the spud had to be raised and the anchor lines slacked, while the swell caused almost invariably washed into the fresh-water tank. I then wrote to the captains of the steamers requesting them to "slow up," officially informing them of the inconvenience they were putting us to, but without any success. On the night of August 4 the steamer Continental, Captain Bown's, ran into the dredge, fortunately striking her in the middle of the stern, for, as the hull is composed of two boats, if either had been struck she would have instantly sunk, or the boiler being struck would have been ruptured or exploded. Knowing that there was abundance of room for the steamer to pass on either side, that the dredge had a light up at the time, and that the general disposition of steamer-captains was not to avoid vessels lying at anchor, I was led to think that the steamboat-men were reckless, and disregarded the public work, besides endangering the lives of the passengers and of those on the dredge. I therefore addressed a communication to the newspapers of New Haven, calling public attention to what appeared to me to be reprehensible in the extreme. The work was delayed several hours by the collision and repairs, and I presume that quite extensive repairs will have to be made when the dredge is laid up, as she was much weakened by the shock, the bow of the steamer going into the stern of the dredge about 7 feet, and breaking, like a pipe-stem, a 12-inch by 12-inch beam. During August the three cuts were completed to the north end of Long Wharf, 47,908 cubic yards being removed, making the channel 150 feet wide and 13 feet deep at mean low water. This is shown in green on the sketch. In September, as the appropriation warranted, a fourth cut was commenced at Black Buoy 5, at the point of commencing of the former

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cut, and continued to north end of Long Wharf, making the channel 200 feet wide; the dredge then commenced to widen the channel between Long Wharf and Canal Dock, making it 350 feet wide. This was rendered necessary by the curve in the channel, and from the fact that numerous vessels use it as an anchorage-ground while waiting for berths at Long Wharf and Canal Dock. This opening up was completed in September, with the exception of a small portion above the south end of Canal Dock. The work for this month amounted to 42,895 cubic yards, shown in orange on the sketch. In October the channel to the steamboat-dock, 13 feet deep at mean low water, and 100 feet wide, was dug thus: the east edge was run on range of Fair Haven Church spire and end of peaked roof of freight-house on Old Belle Dock, the second cut being parallel to and west of the first. When about 300 feet north of north end of Canal Dock cuts were commenced running downward from a line from west edge of channel to end of dock, so as to cut off the corner between the wide and narrow channel. The dredge then hauled back to the channel, and completed the dredging to the steamboat-dock on October 31, having taken out, in ninety-eight days, 772 scow-loads, 153,817 cubic yards; having been laid up but two whole days on account of breakdowns—one when the spud broke from the effects of a heavy gale, and the other spent in replacing friction-clutches, so that in ninety-six working days 153,817 cubic yards were removed, or 1,600 cubic yards per day, which rate has, I believe, never been exceeded for so extended a period of time, although for a single day Morris & Cummings have, with one dredge, taken out 3,600 cubic yards. The contractors are deserving of favorable mention for the manner in which they performed the work, and their strict adherence to the directions of the superintendent, Mr. Mather, from whose careful attention has resulted the successful prosecution of the work. On November 17 and 18 a survey was made of the channel dredged, in the following manner: Buoys were anchored on the edge of the channel, for convenience in sounding, and lines of soundings run across the channel, both edges being located by two transits, intermediate soundings being taken at equal intervals across the channel. Other lines were also run down the channel, to ascertain if any shoal spots existed. The soundings were reduced to mean low water at Long Wharf. A map has been made of the channel, on a scale of $\frac{1}{2500}$, before and after dredging. In this the green line represents 6-foot curve, broken black lines 9-foot curves, full red line 12-foot curve, before dredging; broken line (red) the channel as dredged; black figures, soundings before dredging; red figures, soundings after dredging. It will be seen that in no case is there less than 12.5 feet in the dredged channel, and then only on lumps so small that the sounding-lead would scarcely rest upon them, and which would be knocked over by anything striking them. From this survey, then, the following conclusions may be drawn: a channel 200 feet wide and 13 feet deep at mean low water has been dredged from Black Buoy No. 5 to Long Wharf, a channel of same depth, 350 feet wide, from Long Wharf to Canal Dock, and one 100 feet wide from Canal Dock to Steamboat Dock. As a result of this several vessels, drawing from 13 to 19 feet, have gone up to the dock without previous lightering, and numerous others, drawing from 9 to 13 feet, have been towed up without waiting for the tide as heretofore. A survey of the dumping-ground was made November 3, the soundings being located by two sextants, and reduced to mean low water at Five-Mile Point; eighty soundings were taken, and showed no perceptible diminution of depth. A map of this will be made, and a comparison of the depths with those on the United States Coast Survey, for the purpose of ascertaining to what extent the dumping has affected the bottom.

REMOVAL OF LUDDINGTON'S ROCK.

Work was commenced on Luddington's Rock first, for the reason that it was a more formidable obstruction than Middle Rock, lying as it does directly in the west channel of the harbor, having only 9.8 feet over it at mean low water, and having been struck several times by vessels, which were badly injured, while Middle Rock has never been struck. Mr. Eugene Sullivan's blasting sloop arrived at New Haven on July 29, and after placing dualine and powder in the magazine at month of Morris Creek, on the 31st the mooring-stones were taken aboard from Long Wharf, and on August 1, the sloop went out to Luddington's Rock. Upon sounding I found that the H. S. buoy placed on the rock by the tender Putnam, belonging to the Light-House Board, was on the highest point of the rock. On the 1st and 2d the mooring-stones and buoys were put down so that the vessel could be moored with the tide west-northwest and east-southeast. The divers reported the rock to be covered with rock-weed and the water to be very thick, the limit of vision being about a foot. Operations commenced on August 3, by the use of surface and face blasts of dualin and powder, about eight tons of rock being taken up. First deck-load of stone, amounting to forty-six and one-half tons, was discharged on August 8, having been removed entirely by face and surface blasts; the work commencing on the west side of the sand-gulley and progressing westward. To remove this amount of rock (21.21 cubic yards) were required 100 pounds of dualin and 265 pounds of powder, this being at the rate of

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two pounds of dualin and four pounds of powder for every ton of rock. As there were four and one-half working days, the amount removed per day was ten tons. This large increase over the rate last year from the same kind of blasting is due to the superior convenience of Mr. Sullivan's vessel, and more especially to the competency of himself and assistant diver. I made three determinations of the specific gravity of the rock, and found it to be 2.599; weight of a cubic yard 4,385.61 pounds. The method of weighing will be alluded to hereafter. The next deck-load of stone was discharged on August 17, and consisted of 44½ tons, and was removed by face and surface blasts of 140 pounds of dualin and 400 pounds of powder, being three and one-fifth pounds of dualin and nine pounds of powder per ton. During this time there were five and one-half working days—rock being removed at the rate of eight tons per day. Finding that surface and face blasts removed the rock too slowly, Mr. Sullivan put in order his Burleigh drill, worked by steam from the hoisting-engine on deck. This drill was mounted on an iron tripod 23 feet long, weighing over a ton, and having adjustable legs to adapt it to the inequalities in the rock—the drill being secured in a joint which allowed it to drill at any angle within the triangle formed by the tripod legs. Mr. Sullivan was well suppled with drills, (having forty in all, of various lengths,) the edges being ×-shaped. He also had a portable forge and an experienced man to sharpen the drills, so that no time was lost in replacing a dull drill. The Burleigh drill worked as well as could be expected, when running under water, and having a drill-shaft 20 feet long to lift; frequently drilling 7 feet an hour, running time. When it is stated that in the operations at Middle Rock last year, the best progress made by Townsend's drill was 8 inches in an hour, but little further comment will be necessary on the relative rapidity of removing rock in 1870 and 1871. On August 31, a deck-load of stone was discharged of 27½ tons. Five holes, total depth 15 feet, had been drilled, and 60 pounds of dualin and 212 pounds of powder exploded—or 2½ pounds of dualin and 8 pounds of powder per ton. There were seven working days, during this time, stone being removed at the rate of 4 tons per days; much time being lost owing to wind. Much difficulty was experienced in working the drill, as the boiler was not large enough to keep up steam, the drill requiring 80 pounds at least, on account of the heavy shaft. During September four deck-loads of stone of 49 tons 1,740 pounds, 36 tons 1,890 pounds, 51 tons 955 pounds, and 20 tons 1,820 pounds, respectively, were discharged. The weight being determined as follows: by the courtesy of the superintendent of New Haven and Northampton Railroad, Mr. Yeomans, I was enabled to weigh the second load upon the scales of the company. The vessel had previously been marked before leaving Boston, and before and after unloading the marks were taken. At this time the marks showed 34½ tons; then for other loads, actual weight $=\text{weight by marks} \times \frac{37\frac{1}{2}}{34\frac{1}{2}}$

The total amount removed during September was 159 tons 405 pounds, or 72.77 cubic yards. Number of working days twenty-one, or 7¾ tons per day; 638 pounds of powder and 217 pounds of dualin being used, or 4 pounds of powder and 1½ pounds of dualin per ton. Five holes were drilled to a total depth of 21.3 feet, at the rate of 7.1 feet per hour, running time. Operations for the year were closed on September 30, there having been removed from the rock in thirty-eight working days 267 tons 1,405 pounds of rock, or 126.85 cubic yards, or at the rate of 7 tons per day, by the expenditure of 1,426 pounds of powder and 549 pounds of dualin, or 2 pounds of dualin and 5½ pounds powder per ton. With a larger boiler the work would proceed faster; and as Mr. Sullivan proposes having one in the spring, there is no reason why the work should not progress with a satisfactory degree of rapidity.

FUTURE IMPROVEMENT.

Taking into consideration the relative positions of the rocks at the entrance to the harbor I would suggest that no further work be done at Middle Rock, for the following reasons: 1st. That the removal of Middle Rock would be of no advantage, except in connection with the removal of B, C., and Southwest Ledge, as the distance between them is so small that unless all were removed the channel would not be materially widened. 2d. Middle Rock is not in either channel, but on one side of East Channel, in which there is more water than would be obtained by its removal, while the Big Boil lies directly in the channel and has been struck several times by vessels, as it is not laid down upon any chart. I would therefore recommend the removal of the Big Boil and the continuance of the operations for the removal of Luddington's Rock. I submit the following estimate for the removal of Big Boil to 17 feet below mean low water, and for the completion of the removal of Luddington's Rock to 16 feet below mean low water:

To remove Big Boil, 586.71 cubic yards, at $25	$14,667 75
To remove Luddington's Rock, 695.02 cubic yards, at $25	17,375 51
To remove both rocks	32,043 25

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The removal of these rocks with the same degree of rapidity as that taken out by Mr. Sullivan this year will require three hundred and eighty-five working-days, but with increased boiler room, so that the drill can be properly worked, there is no reason why this rate should not be doubled, especially as the Big Boil is well adapted for blasting. I would also suggest the dredging of the sand-bar between Fort Hale and the light-house, but consider it is a subject requiring reflection, for unless the improvement is to be in some degree permanent it will be worse than useless to prosecute it. If the sand in New Haven Harbor moves as in some of the sound harbors a channel through the bar would not stay open a single season, and it is too expensive an undertaking to be commenced without a fuller knowledge of the tidal currents than we have at present. If the direction of the currents is nearly identical with that of the proposed channel, it would, I think, remain open, as the scour would be sufficient to prevent deposit, especially as Five-Mile Point forms a natural breakwater, protecting the inner harbor from the swell of a southeast storm, the only cause in addition to the tidal currents that would make an accumulation of sand. I would therefore suggest that sufficient current observations be made to determine velocity and direction of the tidal currents in the stratum of water next to the bottom, and that after having obtained the general direction of the ebb and flood currents perforated boxes be so placed as to collect the sand if any is in motion over the bar. That there is no deposit going on at present is evident from a comparison of the reduced soundings made in 1871 with those of the United States Coast Survey, so that the sand movement can only be detected by placing an obstacle in its path. In case these observations prove favorable I submit the following estimate of the cost of dredging a channel 200 feet wide and 16 feet deep at mean low water through the bar. The average depth of dredging is about 2 feet, and distance to be dredged 5,000 feet, therefore amount to be excavated = $\frac{200 \times 5{,}000 \times 2}{27}$ cubic yards, = 74,747.4 cubic yards, which, at 35 cents, is $26,161.60. The material, being comparatively soft sand, could be dredged at this rate, especially as the dumping-ground is only two and one-half miles from the bar. The iron spindle-socket on Southwest Ledge should be removed, as it is a dangerous obstacle in the path of small vessels. This would require the expenditure of not over $100. The total amount required to prosecute the improvement would be as follows:

For removal of rocks	$32,043 [illegible]
For dredging bar	26,161 [illegible]
For removing spindle	100 [illegible]
For current observations	250 [illegible]
Total	58,554 [illegible]

The importance of the harbor will warrant this expenditure, as the city is the terminus of railroads supplying a large section of the interior, as will be seen by the annexed statistics of the commerce of New Haven. Numerous vessels drawing from 14 to 19 feet are delayed by waiting for the tide to cross the bar, while if the bar was dredged and the channel buoyed the harbor would become *the* refuge harbor on the sound.

I am, general, yours, very respectfully,

GEORGE H. MANN.
Civil Engineer.

Brevet Major-General G. K. WARREN,
Major Engineers, United States Army.

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NEW HAVEN HARBOR.—*Tide observations at Chapel Street Bridge.*

Mean sea-level, 4.932.

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.
March 18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 22	.....	.....	.....	1.75	.7	.65	.63	.62	.67	.7	.82	2.0	.23
March 23	.....	.....	.....	.....	.....	.....	1.35	.4	.45	.5	.6	.7	.8
March 24	.....	.....	.....	.....	.....	.....	.....	.....	1.32	.22	.12 .07	.10	.18
March 25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.85	.75	.65
March 26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 31	.....	.....	.....	.....	.....	.....	.....	7.4	.5 .48	.48	.4	.35	.3
April 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.47	.55
April 2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 7	.....	.....	.....	1.25	.18	.07	.0	0.95	1.02	.2	.42	.65	.9
April 8	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.18	.1	.0	0.91
April 9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 14	.....	.....	.....	7.49	.59	.75	.89	.98	8.09	.15	.21 .20	.20	.18
April 15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.9

Date.	7.40 a. m.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.
March 18	.....	.....	.....	.....	.....	.....	.....	.....	8.1	.13	.20	.22	.26
March 19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 22	.60	.75	.9	3.1	.3	.5	.75	4.0	.3	.6	.8	.95	5.15
March 23	.95	2.1	.4	.6	.85	3.05	.20	.40	.67	.97	4.25	.5	.8
March 24	.20	.17	.15	.20	.28	.5	.8	2.0	.1	.25	.42	.65	.85
March 25	.55	.45	.35	.25	.25	.32	.45	.52	.6	.66	.76	.93	2.05
March 26	.....	.....	1.25	.22	.2	.1	.098 .0 .0	.....	.05	.1	.1	.17	.3
March 27	.....	.....	.....	.....	.....	.....	5.1	.1	.1	.0	4.9	.9	.95
March 28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 31	.15	.0	6.9	.75	.6	.4	.3	.22	.12	5.9	.68	.43	.25
April 1	.65	.75 .72	.72	.7	.62	.6	.5	.38	.3	.18	.7	6.97	.8
April 2	.....	.....	.....	8.4	.47	.55	.65	.62	.57	.45	.....	.....	.....
April 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.28	.36	.46	.46
April 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 7	2.08	.26	.43	.62	.86	3.01	.37	.65	.40	.33	.67	.9	5.17
April 8	.93	1.0	.2	.45	.7	.9	2.1	.32	.57	.82	3.05	.3	.55
April 9	.....	.....	1.38	.42	.49	.53	.55	.61	.8	.98	2.2	.45	.77
April 10	.....	.....	.....	.....	2.0	1.9	.79	.65	.62	.68	.69	.78	.85
April 11	.....	.....	.....	.....	.....	.....	.....	.....	3.2	.0	2.83	.71	.68
April 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 14	.08	7.96	.8	.68	.48	.35	.21	.0	6.85	.72	.4	.15	5.98
April 15	8.0	.1	.2	.28	.29	.27	.23	.05	7.89	.68	.50	.35	.22

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Tidal observations at Chapel Street Bridge—Continued.

Date.	9.50 a. m.	10 a. m.	10.10 a. m.	10.20 a. m.	10.30 a. m.	10.40 a. m.	10.50 a. m.	11 a. m.	11.10 a. m.	11.20 a. m.	11.30 a. m.	11.40 a. m.	11.50 a. m.
March 18	.20	.0	7.9										
March 19	8.05	.1	.2	.15	.1	.0	7.95	.8	.6	.4	.2	.0	
March 20		8.0	.1	.3	.4	.5	.6	.6	.5	.45	.35	.25	
March 21					8.7	.8	.9	9.0	.05	.17	.20	.1	
March 22	.45	.65	.85	6.05	.25	.45	.62	.8	.97	7.15	.30	.35	
March 23	5.0	.29	.57	.8	6.0	.02	.39	.6	.9	7.15	.4	.45	
March 24	3.05	.3	.5	.75	.95	4.15	.35	.65	.9	5.15	.25	.45	
March 25	.2	.4	.6	.7	.85	3.05	.2	.4	.5	.7	.37	4.06	
March 26	.45	.5	.8	2.0	.25	.45	.6	.8	3.0	.2	.3	.5	
March 27	5.1	.1	.15	.25	.30	.4	.55	.65	.7	.8	.9	6.05	
March 28		2.68	.6	.53	.6	.66	.75	.8	.95	2.03	.12	.15	
March 29					2.3	.2	.2	.15	.2	.2	.15	.15	
March 30											2.6	.5	
March 31	.13	.0	4.9	.78	.62	.4	.23	.07	3.9	.7	.5	.21	
April 1	.65	.45	.32	.0	5.81	.6	.39	.02	.02	4.9	.72	.50	
April 2													
April 3	.40	.32	.27	.10	8.95	.8	.6	.35	.1	7.87	.62	.49	
April 4		8.9	.95	.98	.98	.9	.8	.63	.41	.2	.0	7.7	
April 5				7.3	.4	.43	.43	.5	.45	.4	.4	.3	
April 6										8.66	.74	.52	
April 7	.47	.6	.86	6.15	.47	.77	.95	7.2	.48	.63	.8	.95	
April 8	.83	4.27	.5	.77	5.05	.3	.5	.7	.96	6.2	.43	.17	
April 9	.97	3.2	.4	.62	.85	4.12	.37	.63	.9	5.2	.46	.67	
April 10	.9	2.0	.13	.33	.65	.68	3.05	.28	.4	.61	.32	4.15	
April 11	.61	.57	.6	.69	.61	.6	.62	.69	.85	3.05	.32	.35	
April 12		3.05	2.94	3.0	2.78	.7	.55	.37	.28	.2	.2	.34	
April 13									3.1	2.9	.74	.28	
April 14	.81	.6	.35	.15	4.97	.76	.59	.4	.2	.05	3.9	.25	
April 15	.07	6.85	.69	.38	.13	5.98	.79	.52	.30	.10	4.91	.70	

Date.	12 m.	12.10 p. m.	12.20 p. m.	12.30 p. m.	12.40 p. m.	12.50 p. m.	1 p. m.	1.10 p. m.	1.20 p. m.	1.30 p. m.	1.40 p. m.	1.50 p. m.	2 p. m.
March 18													
March 19	.55	.3	5.95	.8	.6	.32	.1	4.8	.5	.3	.15	3.9	
March 20	7.9	.7	.5	.25	.0	6.75	.5	.2	.1	5.9	.7		
March 21	.02	.0	8.8	.55	.37	.05	7.72	.55	.30	.0	6.9	.15	
March 22	.42	.45	.5	.47	.45	.15	.05	6.92	.75	.65	.46	.25	
March 23	.72	.8	8.1	.15	.15	.30 .25	.26	.15	.20	.0			
March 24	.75	.95	6.2	.3	.45	.6	.75	.9	7.0	.1	.15	.65	
March 25	.4	.47	.55	.8	.93	5.15	.35	.4	.55	.67	.35	.17	
March 26	.95	4.15	.35	.55	.75	.95	5.05	.3	.45	.55	.63	.27	
March 27	.45	.55	.70	.75	.75	.8	.9	7.0	.1	.2	.25	.22	
March 28	.50	.60	.70	.82	4.0	.28	.46	.6	.74	.9	5.1	.15	
March 29	.3	.37	.45	.57	.62	.8	.95	3.1	.35	.47	.60	.11	
March 30	.57	.6	.55	.49	.5	.57	.62	.75	.8	.9	3.25	.1	
March 31	.08	.0	2.88	.78	.71	.67	.67	.67	.67	.68	.70	.11	
April 1	.27	.18	3.99	.75	.66	.59	.52	.43	.25	.1	2.99	.8	
April 2													
April 3	.01	6.79	.51	.27	.0	5.72	.42	.19	.05	4.9	.67	.6	
April 4	.33	.1	6.9	.6	.33	.11	5.86	.6	.3	.01	4.8	.21	
April 5	.0	6.72	.55	.25	.0	5.76	.5	.25	.0	4.72	.5	.15	
April 6	.69	.7	.63	.5	.3	.07	7.86	.63	.40	.12	6.9	.7	
April 7	.21	.35	.5	.55	.6	.55	.45	.4					
April 8	7.12	.40	.59	.77	.9	8.0	.1	.25	.37	.37	.35	.1	
April 9	6.1	.35	.56	.80	7.1	.3	.4	.6	.77	5.07	.10	.2	
April 10	.52	.8	5.03	.3	.42	.6	.79	.92	6.27	.52	.8	.15	
April 11	.95	4.28	.48	.7	.58	5.1	.52	.48	.62	.8	6.05	.35	
April 12	.66	.85	.99	3.1	.19	.19	.33	.65	.9	4.17	.4	.6	
April 13	.35	.25	.15 .17	.16	.2	.26	.3	.34	.38	.5	.72	.9	
April 14	.35	.2	.1	2.9	.77	.57	.4	.36	.39	.47	.49		
April 15	.36	.12	3.92	.79	.60	.45	.27	.02	2.97	.32	.7	.2	

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Tide observations at Chapel Street Bridge—Continued.

Date.	2.10 p. m.	2.20 p. m.	2.30 p. m.	2.40 p. m.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.
March 18	.....	.....	2.1	1.95	.82	.7	.59	.6	.6	.5	.45	.55	.6
March 19	.5	.25	.05	2.9	.63	.4	.2	1.95	.75	.65	.6	.58	.55
March 20	4.95	.8	.5	.25	.1	3.85	.65	.45	.20	2.95	.8	.55	.4
March 21	.2	5.9	.55	.25	.0	4.75	.55	.35	.05	.0	3.85	.65	.45
March 22	.7	.5	.3	.05	4.8	.6	.35	.05	3.95	.75	.55	.35	.15
March 23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 24	.03	.03	6.9	.7	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 25	.9	.9	.85	.8	.75	.65	.45	.....	.....	.....	.....	.....	.....
March 26	6.1	.33	.35	.48	.48	.45	.45	.41	.35	.28	.....	.....	.....
March 27	.45	.42	.4	.47	.45	.53	.53	.44	.4	.23	.15	.....	.....
March 28	.55	.70	.85	6.1	.25	.4	.55	.7	.8	.85	.90	.95	7.0
March 29	4.1	.3	.5	.65	.8	.95	5.1	.2	.3	.47	.6	.75	.8
March 30	.49	.6	.8	.95	4.05	.2	.3	.47	.67	.85	5.15	.2	.37
March 31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 1	3.02	.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 2	.....	3.01	2.9	.88	.92	.93	.92	.95	.99	3.02	.....	.....	.....
April 3	3.98	.78	.65	.5	.35	.19	.1	2.95	.83	.73	.7	.72	.78
April 4	.10	.0	3.8	.6	.4	.2	.0	2.8	.5	.3	.1	.0	1.9
April 5	.65	.40	.1	2.9	.72	.55	.28	.0	1.6	.5	.36	.25	.1
April 6	.2	5.95	.62	.32	.02	4.83	.5	.3	.01	3.82	.6	.32	.02
April 7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 9	.47 / .45	.45	.43	.42	.3	.....	.....	.....	.....	.....	.....	.....	.....
April 10	.28	.33	.68	.79	.9	.99	8.02	.02	.02	.0	7.9	.....	.....
April 11	.85	.95	7.2	.4	.5	.6	.84	8.01	.23	.27	30	.45	.48
April 12	5.0	.2	.4	.6	.78	.91	6.11	.31	.4	.55	.78	7.03	.18
April 13	.31	.46	.69	.88	4.11	.30	.55	.77	.94	5.15	.4	.7	.88
April 14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 15	.47	.44	.41 / .44	.44	.49	.57	.....	.....	.....	.....	.....	.....	.....

Date.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.50 p. m.	5 p. m.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.
March 18	.9	.95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 19	.50	.35	.3	.35	.5	.65	.....	.....	.....	.....	.....	.....	.....
March 20	.2	.05	.0	1.95	.85	.8	.85	.85	.90	2.05	.0	.....	.....
March 21	.15	2.9	.7	.5	.25	.15	.15	.2	.2	.1	.0	.0	.1
March 22	2.95	.7	.55	.35	.2	.0	1.85	.7	.6	.55	.5	.45	.4
March 23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 28	.0	.0	.95	.8	.8	.....	.....	.....	.....	.....	.....	.....	.....
March 29	.97	6.1	.2	.27	.3	.3	.32	.35	.37	.42	.4	.35	.35
March 30	.49	.6	.72	.85	6.0	.25	.37	.5	.7	.75	.8	.75	.77
March 31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 4	.82	.8	.7	.72	.83	.93	.....	.....	.....	.....	.....	.....	.....
April 5	.98	.8	.78	.7	.65	.52	.45	.42	.5	.67	.....	.....	.....
April 6	2.82	.6	.4	.15	1.90	.7	.52	.45	.38	.3	.25	.26	.31
April 7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 11	.55	.64	.62	.46	.3	.....	.....	.....	.....	.....	.....	.....	.....
April 12	.3	.45	.6	.69	.8	.9	.98	8.02	.05	7.98	.91	.....	.....
April 13	.99	6.1	.28	.51	.78	.97	7.1	.3	.45	.5	.7	.85	.9
April 14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

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Tide observations at Chapel Street Bridge—Continued.

Date.	6.30 p. m.	6.40 p. m.	6.50 p. m.	7 p. m.	7.10 p. m.	7.20 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall
							Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*F.*
March 18								5	6 9			
March 19							8	5	6 28½			
March 20							10	10	6 15			
March 21	.25	.5	.8				0	10	6 35			
March 22	.4	.4	.45	.6	.8		15	{10 / 20}	6 17½	5 37½	5.88	6.1
March 23							0	5		6 17½	6.90	
March 24							0	0		6 25	6.08	
March 25							20	10		6 5	4.65	
March 26							10	0		6 0	5.50	
March 27							10	10		5 40	2.63	
March 28							20	5		6 22½	4.47	
March 29							0	10		6 15	4.22	
March 30	.82	.8	.75				0	0		6 40	4.33	
March 31							0	35	6 17½			
April 1							0	5	5 59½			
April 2							5	5	5 55			
April 3							10	10	6 15			
April 4							15	5	6 20			
April 5							10	5	6 42½			
April 6	.42						5	5	6 30			
April 7							10	5		5 57½	7.65	
April 8							20	5		5 57½	7.46	
April 9							0	5		6 12½	7.09	
April 10							25	5		6 25	6.40	
April 11							0	0		6 37½	6.07	
April 12							5	10		6 12½	5.45	
April 13	8.03	.17	1	{.2 .21}	.16	{7.96}	0	0		6 40	6.08	
April 14							0	0	6 05			
April 15							5	0	5 32½			

NEW HAVEN HARBOR.—*Tide observations at Long Wharf.*

Mean sea-level 5.189.

[At Chapel Street Bridge it was 4.932; diff.=.257; so the readings at Long Wharf were reduced

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.
March 18													
March 19													
March 20													
March 21													
March 22	1.6	.5	.45	.4	.4	.35	.35	.4	.5	.65	.8	2.05	.3
March 23						1.3	.3	.35	.4	.5	.6	.7	.8
March 24									1.1	.0	0.95	1.0	.85
March 25										1.85	.75	.55	.55
March 26													
March 27													
March 28													
March 29													
March 30													
March 31				7.3	.4	.45	.45	.5	.5	.47	.43	.37	.3
April 1												7.5	.6
April 2													
April 3													
April 4													
April 5													
April 6													
April 7				.85	.85	{.72 .78}	{.75}	.8	.9	1.09	.3	.59	.75
April 8									1.02	.0	0.9	.8	.75
April 9													
April 10													
April 11													
April 12													
April 13													
April 14					7.7	.9	8.0	.1	.17	.2	.22	.2	.15
April 15										7.7	.8	.95	.6

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Tide observations at Long Wharf—Continued.

Date.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.	9.50 a. m.	10 a. m.
March 18	.....	.....	.....	.....	7.9	6.0	.1	.1	.2	.3	.3	.3	.2	.0
March 19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.0	.1	.2	.2
March 20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 22	.7	.9	3.1	.4	.65	.9	4.2	.45	.65	.85	5.1	.3	.5	.7
March 23	2.15	.4	.65	.9	3.1	.3	.6	.95	4.2	.45	.75	5.0	.25	.55
March 24	.05	.1	.15	.25	.5	.8	2.0	.2	.35	.6	.8	3.0	.2	.45
March 25	.35	.25	.2	.25	.35	.45	.5	.6	.7	.8	.9	2.1	.3	.5
March 26	.....	.....	1.2	.1	.0	0.95	.95	1.0	.03	.1	.2	.3	.45	.55
March 27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.52
March 29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 31	6.95	.8	.65	.5	.4	.3	.15	.0	5.8	.6	.35	.22	.1	4.97
April 1	{.72 .72}	.7	.67	.62	.57	.5	.4	.3	.1	.0	6.9	.7	.55	.35
April 2	.....	.....	.....	8.55	.65	{.7 .7}	.67	.6	.5	.....	.....	.....	.....	.....
April 3	.....	.....	.....	.....	.....	.....	.....	.....	9.4	.47	.5	.5	.45	.4
April 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.85	.95
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 7	2.18	.3	.55	.85	3.08	.50	.8	4.08	.29	.50	.95	6.25	.45	.7
April 8	.91	.97	1.32	.52	.84	2.1	.38	.65	.92	3.2	.48	.78	4.8	.4
April 9	1.4	{.35 .36}	.38	.45	.48	.55	.64	.8	2.05	.35	.55	.8	3.07	.45
April 10	.....	.....	.....	1.9	.75	.66	.6	.6	.62	.7	.75	.8	.9	2.0
April 11	.....	.....	.....	.....	.....	.....	.....	3.0	2.81	.71	.7	.6	.6	.65
April 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.95
April 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 14	.05	7.9	.8	.65	.45	.3	.2	.0	6.75	.5	.3	.05	5.9	.7
April 15	.23	.35	.35	.32	.27	.2	.13	.0	7.8	.65	.57	.4	.2	.0

Date.	10.10 a. m.	10.20 a. m.	10.30 a. m.	10.40 a. m.	10.50 a. m.	11 a. m.	11.10 a. m.	11.20 a. m.	11.30 a. m.	11.40 a. m.	11.50 a. m.	12 m.	12.10 p. m.	12.20 p. m.
March 18	7.8	.6	.4	.3	.1	6.8	.6	.4	.2	5.9	.6	.3	.0	4.8
March 19	.2	.2	.1	.0	7.9	.8	.6	4.	.1	6.9	1.	.4	.2	5.9
March 20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 21	.....	.....	.....	.....	.....	.....	.....	9.25	.2	.15	.1	.05	.0	8.8
March 22	.9	6.1	.3	.5	.7	.9	7.1	.2	.3	.35	.45	.45	.45	.45
March 23	.75	6.0	.25	.4	.65	.9	7.1	.35	.45	.6	.75	.9	8.0	.1
March 24	.75	4.0	.2	.45	.6	.85	5.0	.25	.40	.6	.8	.95	6.15	.35
March 25	.65	.8	3.05	.15	.35	.55	.7	.9	4.05	.2	.35	.55	.7	.8
March 26	.72	.97	2.2	.4	.6	.8	3.0	.2	.4	.6	.8	4.0	.22	.45
March 27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
March 28	.5	.55	.6	.7	.8	.9	3.0	.1	.25	.4	.5	.6	.7	.85
March 29	.....	.....	2.2	.15	.15	.15	.13	.1	.18	.17	.25	.35	.4	.6
March 30	.....	.....	.....	.....	3.2	2.8	.7	.6	.5	.5	.55	.5	.5	.55
March 31	.85	.7	.5	.35	.2	.0	3.75	.57	.37	.2	.1	.0	2.9	.75
April 1	.12	.0	5.75	.55	.35	.2	.0	4.75	.6	.45	.3	.15	.0	3.85
April 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.3	.15	8.92	.82	.52	.3	.1	7.87	.65	.4	.2	6.92	.6	.37
April 4	.95	.95	.95	.85	.70	.50	.35	.1	7.9	.7	.45	.15	6.9	.6
April 5	7.2	.3	.35	.35	{.45 .42}	.42	.35	.3	.3	.2	.1	6.95	.7	.35
April 6	.....	.....	.....	.....	.....	8.48	.6	.7	.72	.7	.7	.68	.68	.6
April 7	.95	6.28	.55	.76	7.07	.3	.55	.75	.81	.91	8.09	.23	.35	.5
April 8	.75	5.0	.25	.5	.7	.32	6.12	.37	.62	.87	7.09	.3	.5	.75
April 9	.58	.75	4.1	.4	.6	.9	5.15	.4	.6	.85	6.08	.3	.48	.75
April 10	.15	.40	.7	.95	3.2	.37	.55	.85	4.0	.25	.5	.78	5.0	.25
April 11	.69	.60	.6	.7	.67	.8	.9	3.12	.32	.52	.92	.42	.4	.62
April 12	.9	.85	.7	.59	.42	.30	.22	.20	.28	.41	.57	.73	.93	3.05
April 13	.....	.....	.....	.....	.....	.....	.....	2.80	.65	.52	.42	.32	.21	.16
April 14	.5	.25	.05	4.8	.65	.45	.3	.15	3.95	.8	.6	.4	.2	.1
April 15	6.7	.4	.2	.0	5.8	.6	.4	.2	.0	4.75	.55	.4	.2	3.9

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Tide observations at Long Wharf—Continued.

Date.	12.30 p. m.	12.40 p. m.	12.50 p. m.	1 p. m.	1.10 p. m.	1.20 p. m.	1.30 p. m.	1.40 p. m.	1.50 p. m.	2 p. m.	2.10 p. m.	2.20 p. m.	2.30 p. m.	2.40 p. m.
March 18	.7	.4	.2	3.9	.6	.3	.1	2.9	.7	.6	.4	.2	.0	
March 19	.7	.5	.2	4.9	.65	.4	.1	3.9	.7	.5	.3	.1	2.9	
March 20														
March 21	.55	.25	.0	7.7	.5	.25	.0	6.85	.65	.35	.1	5.75	.35	
March 22	.4	.3	.15	6.95	.8	.65	.45	.30	.1	5.8	.6	.3	.1	
March 23	.2	.3	.2	.15	.1	.0	7.9							
March 24	.6	.75	.9	7.0	.1	.2	.1	.05	.0	6.95				
March 25	.95	5.05	.25	.4	.5	.7	.8	.9	.95	.95	.9	.85	.8	
March 26	.62	.82	5.02	.17	.35	.52	.65	.75	.9	6.1	.2	.3	.4	
March 27													7.5	
March 28	4.05	.3	.5	.7	.85	.95	5.15	.3	.45	.6	.75	.95	6.1	
March 29	.75	.95	3.1	.3	.5	.65	.75	.9	4.1	.3	.5	.6	.8	
March 30	.55	.57	.65	.75	.80	.9	3.0	.15	.35	.5	.65	.8	.95	
March 31	.7	.65	.6	.6	.6	.62	.65	.7						
April 1	.7	.55	.45	.45	.3	.15	.0	2.9	.85	.9	3.0	.05		
April 2												2.95	.9	
April 3	.1	5.8	.6	.4	.15	4.95	.7	.5	.25	3.95	.8	.6	.3	
April 4	.4	.1	5.8	.5	.2	4.95	.75	.5	.25	.0	3.8	.6	.3	
April 5	.15	5.85	.6	.3	.09	4.85	.59	.25	3.98	.7	.4	.1	2.5	
April 6	.4	.2	.0	7.71	.45	.21	.0	6.67	.5	.29	5.97	.72	.4	
April 7	.53	.58	.5	.4										
April 8	.72	8.05	.14	.24	.35	.4	{.45 {.42	}.43	.3	.25				
April 9	7.0	.22	.4	.6	.7	.9	8.1	.18	.3	.35	.4	.49	.5	
April 10	.47	.6	.75	6.0	.25	.45	.7	.9	7.07	.2	.4	.6	.2	
April 11	.8	5.03	.29	.56	.66	.86	6.07	.38	.52	.79	.62	7.1	.35	
April 12	.07	.13	.32	.68	.90	4.1	.4	.66	.85	5.0	.15	.37	.51	
April 13	.16	.20	.23	.28	.37	.48	.63	.82	3.01	.23	.46	.63	.2	
April 14	2.95	.85	.65	.45	.4	.4	.45	.47	.5	.6				
April 15	.7	.55	.35	.2	.0	2.9	.8	.7	.55	.5	.4	.4	.35	

Date.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.50 p. m.
March 18	.7	.6	.5	.4	.4	.3	.4	.5	1.7	.8			
March 19	.5	.2	.0	.18	.62	.52	.5	.42	.4	.32	.22	.22	.3
March 20													
March 21	4.85	.65	.40	.15	.0	3.9	.7	.4	.1	2.8	.6	.3	.2
March 22	.6	.4	.1	3.9	.7	.5	.3	.0	2.8	.6	.4	.3	.1
March 23													
March 24													
March 25	.65												
March 26	.45	.5	.45	.4	.3	.25							
March 27	{.57 {.55	}.55	.5	.45	.25								
March 28	.45	.55	.65	.7	.85	.9	.95	.95	.95	7.0	.07	.0	6.95
March 29	.15	.25	.4	.5	.6	.75	.85	.95	6.1	.2	.25	.25	.3
March 30	.2	.3	.5	.7	.9	5.1	.25	.4	.6	.7	.9	6.05	.15
March 31													
April 1													
April 2	.89	.89	.9	.92	.97	3.0							
April 3	.15	2.9	.85	.75	.7	.65	.6	.6	.67	.77			
April 4	2.9	.7	.5	.3	.1	1.9	.85	.75	.7	.7	.65	{.6 {.6	{.6 }
April 5	.4	.25	1.91	.7	.45	.3	.08	0.95	.75	.65	.55	.5	.5
April 6	4.7	.55	.28	.0	3.8	.45	.25	.0	2.75	.55	.30	.12	1.2
April 7													
April 8													
April 9	.3												
April 10	.97	8.1	.12	.12	.08	.0							
April 11	.6	.8	8.02	.25	.25	.25	.45	.52	.55	.7	.65	.5	
April 12	.9	6.05	.27	.41	.57	.75	7.0	.2	.3	.36	.65	.73	.9
April 13	.25	.50	.69	.9	5.12	.41	.65	.82	6.0	.05	.21	.41	.7
April 14													
April 15	.4	.5											

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Tide observations at Long Wharf—Continued.

Date.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.	6.30 p. m.	6.40 p. m.	6.50 p. m.	7 p. m.	7.10 p. m.	7.20 p. m.
March 18														
March 19	.6	.8												
March 20	1.9	.8	.8	.9	2.1	.3								
March 21	.0	.0	.1	.0	1.9	.9	.95	2.05	.2	.4				
March 22	.75	.6	.5	.4	.3	.25	.25	.25	.3	.4	.5	.75	.95	2.1
March 23														
March 24														
March 25														
March 26														
March 27														
March 28														
March 29	.35	.4	.4	.4	.35	.35	.25							
March 30	.4	.55	.65	.7	.73	.7	.75	.85	.85	.8				
March 31														
April 1														
April 2														
April 3														
April 4														
April 5	.25	.2	.25	.4	.5									
April 6	.45	.32	.27	.19	.13	.1	.15	.2	.3					
April 7														
April 8														
April 9														
April 10														
April 11														
April 12	8.0	0.5	.1	.08	.0	7.91								
April 13	7.08	.26	.44	.5	.67	.8	.91	8.02	.2	.2	.15	.22	.2	.0
April 14														
April 15														

Date.	7.30 p. m.	7.40 p. m.	7.50 p. m.	8 p. m.	8.10 p. m.	8.20 p. m.	8.30 p. m.	8.40 p. m.	8.50 p. m.	9 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall.
											Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*
March 18											10	0	6 5			7.00
March 19											30	10	6 30			6.98
March 20											(*)	10	(*)			(*)
March 21											0	10	6 35			7.35
March 22	.3	.5									20	10 20	6 0	5 45	6.10	6.20
March 23											10	0		6 15	7.00	
March 24											0	0		6 10	6.25	
March 25											10	10		5 45	4.75	
March 26											0	15		6 17½	5.55	
March 27											0	(*)		5 25	2.63	
March 28											0	10		6 25	4.57	
March 29											20	5		6 7½	4.30	
March 30											15	15		6 20	4.35	
March 31											15	20	6 12½			4.90
April 1											5	0	5 57½			4.87
April 2											5	30	6 5			5.81
April 3											15	10	6 22½			6.90
April 4											25	10	6 22½			7.35
April 5											0	10	6 25			7.25
April 6											0	0	6 30			7.62
April 7											5	0		5 47½	7.86	
April 8											0	5		5 57½	7.69	
April 9											5	0		6 22½	7.15	
April 10											15	15		6 25	6.52	
April 11											0	15		6 32½	6.10	
April 12											5	5		6 12½	5.90	
April 13											10	10		6 35	6.06	
April 14											5	20	5 52½			5.82
April 15											15	5	5 30			6.05

* Not determined.

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NEW HAVEN HARBOR.—*Tide observations at Fort Hale.*

Mean sea-level on box, 2.740; with indicator before April 7, 5.151 − 3 } To Chapel Street Bridge gauge.
With indicator after and including, 4.151 + 7 }

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.	7.40 a. m.
March 31	.....	.....	.....	.....	.....	7.3	.3	.4	.3	.25	.2	.2	.15	
April 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.45	
April 2*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 7	.....	.....	.....	1.5	.35	.3	.25	.25	.35	.45	.55	.7	.9	
April 8	.....	.....	.....	.....	.....	1.3	.2	.1	.0	.0	.05	.05	.05	
April 9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 14	.....	.....	.....	.....	.....	.....	7.90	8.0	.10	.15	.15	.15	.10	
April 15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.90	.95	

Date.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.	9.50 a. m.	10 a. m.
March 31	6.8	.7	.6	.5	.3	.25	.0	5.7	.65	.5	.4	.2	4.9	
April 1	.55	.55	.5	.45	.35	.3	.2	.1	6.95	.8	.7	.65	.4	
April 2*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 3	.....	.....	.....	.....	8.8	9.0	.15	.2	.25	.25	.25	.2	.1	
April 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 7	.5	.85	3.0	.15	.4	.75	4.0	.5	.8	5.0	.3	.5	.9	
April 8	.15	.25	.45	.70	.95	2.1	.2	.45	.60	.75	3.25	.60	.95	
April 9	1.60	.50	.45	.40	.45	.50	.55	.70	.95	2.15	.45	.70	3.05	
April 10	.....	.....	.....	.....	1.70	.65	.50	.55	.65	.65	.65	.70	.80	
April 11	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.75	.60	.60	.60	
April 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 14	7.95	.75	.70	.60	.50	.35	.10	6.90	.70	.50	.35	.15	.0	
April 15	.15	.25	.25	.20	.15	.10	.0	7.95	.80	.60	.50	.35	.15	

Date.	10.10 a. m.	10.20 a. m.	10.30	10.40 a. m.	10.50 a. m.	11 a. m.	11.10 a. m.	11.20 a. m.	11.30 a. m.	11.40 a. m.	11.50 a. m.	12 m.	12.10 p. m.	12.20 p. m.
March 31	.7	.45	.4	.2	3.9	.85	.65	.45	.2	.1	2.95	.65	.35	
April 1	5.95	.7	.6	.55	.3	.1	4.9	.7	.5	.45	.2	.0	3.9	
April 2*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 3	8.9	.7	.55	.35	.15	7.9	.65	.45	.15	6.9	.7	.35	5.9	
April 4	8.6	.65	.65	.45	.3	.2	.1	7.9	.7	.55	.3	.05	6.75	
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
April 6	.....	.....	.....	.....	.....	7.85	8.05	.05	.15	.15	.15	.05	.0	
April 7	.4	.6	.9	7.3	.6	.9	8.05	.1	.2	.3	.5	.6	.7	
April 8	.5	.75	5.0	.25	.50	.75	6.0	.25	.55	.70	.95	7.15	.35	
April 9	.50	.70	4.05	.25	.55	.75	5.15	.45	.70	.95	6.15	.30	.50	
April 10	2.20	.35	.55	.70	3.05	.40	.65	.90	4.15	.40	.60	.95	5.15	
April 11	.60	.60	.65	.70	.80	.95	3.05	.30	.60	.90	4.20	.35	.60	
April 12	.....	2.75	.65	.55	.35	.20	.15	.25	.30	.35	.55	.35	.35	
April 13	.....	.....	.....	.....	.....	.....	3.20	2.9	.55	.40	.35	.30	.30	
April 14	.45	.20	.0	4.8	.60	.45	.25	.05	3.85	.60	.45	.35	.10	
April 15	6.70	.55	.30	.05	5.85	.65	.40	.20	4.95	.75	.55	.30	.10	

* No observation, on account of northeast storm.

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Tide observations at Fort Hale—Continued.

Date.	12.30 p. m.	12.40 p. m.	12.50 p. m.	1 p. m.	1.10 p. m.	1.20 p. m.	1.30 p. m.	1.40 p. m.	1.50 p. m.	2 p. m.	2.10 p. m.	2.20 p. m.	2.30 p. m.	2.40 p. m.
March 31	.65	.6	.55	.5	.5	.55	.6	.65	.7	.8	.....	.....	.....	.....
April 1	.6	.5	.3	.2	.05	2.85	.8	.8	.7	.7	.7	.65	.7	.8
April 2*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.6	.3	.1	4.9	.7	.45	.2	3.95	.75	.65	.5	.45	.2	.05
April 4	.2	.0	5.7	.55	.2	4.85	.5	.2	3.95	.8	.55	.3	.1	2.9
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.8	.6	.45	.2	.05	6.9	.75	.45	.0	5.7	.4	.1	4.8	.45
April 7	.9	.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 8	.65	.80	.90	8.05	.15	.25	.20	.15	.....	.....	.....	.....	.....	.....
April 9	7.0	.20	.45	.70	8.0	.25	.40	.55	.70	.85	.85	.75	.60	.....
April 10	.55	.70	.95	6.15	.40	.60	.70	.95	7.25	.35	.45	.70	.90	8.0
April 11	5.00	.20	.50	.65	.80	.95	6.15	.35	.55	.80	7.05	.25	.45	.55
April 12	.15	.30	.55	.85	4.0	.20	.50	.75	.95	5.1	.40	.60	.5	.95
April 13	.25	.30	.35	.40	.50	.65	.70	.85	3.0	.2	.45	.70	.95	4.2
April 14	.75	.60	.50	.40	.30	.20	.20	.25	.35	.40	.....	.....	.....	.....
April 15	.75	.55	.35	.15	2.95	.80	.65	.55	.....	.....	.....	.....	.....	.....

Date.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.50 p. m.	5 p. m.
March 31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 2*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	2.95	.85	.75	.7	.65	.6	.6	.6	.7	.8	.....	.....	.....	.....
April 4	.7	.5	.15	1.85	.55	.45	.2	.0	0.95	.85	.85	.9	.95	1.6
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.1	3.8	.5	.25	2.9	.7	.5	.25	.0	1.8	.7	.4	.15	0.95
April 7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 10	.05	.10	.05	7.95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 11	.70	.85	8.0	.25	.55	.75	.85	.85	.80	.75	.65	.50	.....	.....
April 12	6.20	.35	.45	.55	.65	.90	.85	7.0	.2	.4	.65	.75	.85	.90
April 13	.40	.65	.75	5.0	.20	.35	.55	.75	6.0	.15	.30	.55	.80	.95
April 14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Date.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.	6.30 p. m.	6.40 p. m.	6.50 p. m.	7 p. m.	7.10 p. m.	7.20 p. m.
March 31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 2*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 4	.1	.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.8	.7	.7	.45	.40	.35	.3	.5	.....	.....	.....	.....	.....	.....
April 7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 12	.90	.90	.80	.70	.55	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 13	7.1	.20	.40	.65	.70	.95	.95	.95	.85	.70	.55	.30	.....	.....
April 14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* No observation, on account of northeast storm.

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Tide observations at Fort Hale—Continued.

Date.	7.30 p. m.	7.40 p. m.	7.50 p. m.	8 p. m.	8.10 p. m.	8.20 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall.
							Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*
March 31	.....	.....	.....	.....	.....	.....	5	15	6 32	.....	.....	[illegible]
April 1	.....	.....	.....	.....	.....	.....	0	5	6 37	.....	.....	[illegible]
April 2*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.....	.....	.....	.....	.....	.....	25	25	6 30	.....	.....	[illegible]
April 4	.....	.....	.....	.....	.....	.....	10	15	6 24	.....	.....	[illegible]
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.....	.....	.....	.....	.....	.....	20	5	6 27½	.....	.....	[illegible]
April 7	.....	.....	.....	.....	.....	.....	5	20	.....	5 47½	7.70	.....
April 8	.....	.....	.....	.....	.....	.....	5	10	.....	6 27½	7.25	.....
April 9	.....	.....	.....	.....	.....	.....	10	10	.....	5 45	7.45	.....
April 10	.....	.....	.....	.....	.....	.....	5	10	.....	6 17½	6.65	.....
April 11	.....	.....	.....	.....	.....	.....	20	50	.....	6 24	6.25	.....
April 12	.....	.....	.....	.....	.....	.....	20	10	.....	6 00	5.75	.....
April 13	.....	.....	.....	.....	.....	.....	20	15	.....	6 07½	5.75	.....
April 14	.....	.....	.....	.....	.....	.....	25	10	5 42½	.....	.....	[illegible]
April 15	.....	.....	.....	.....	.....	.....	15	30	5 32½	.....	.....	[illegible]

* No observation, on account of northeast storm.

NEW HAVEN HARBOR.—*Tide observations at Five-Mile Point.*

Mean sea-level on box, 3.158; with indicator, 4.564; .4 to Chapel Street Bridge gauge.

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.	7.40 a. m.
March 31	.....	.....	.....	.....	.....	.....	.....	.....	7.6	.50	.55	.45	.35	[illegible]
April 1	.....	.....	.....	.....	.....	.....	.....	.....	7.35	.40	.50	.60	.70	[illegible]
April 2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 7	.....	.....	1.10	.00	0.90	.90	.90	.95	1.00	.20	.40	.60	.80	[illegible]
April 8	.....	.....	.....	1.50	.40	.00	.00	0.90	.85	.80	.80	.85	.90	[illegible]
April 9	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.60	.50	.40	.30	[illegible]
April 10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.90	.75	[illegible]
April 11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 14	.....	.....	.....	.....	.....	.....	.....	8.00	.05	.10	.10	.10	.00	[illegible]
April 15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Date.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.	9.50 a. m.	10 a. m.
March 31	.25	.05	6.90	.80	.65	.40	.30	.10	5.90	.80	.50	.40	.30	[illegible]
April 1	.75	.75	.75	.70	.60	.55	.40	.35	.20	.10	6.90	.80	.60	[illegible]
April 2	.50	.70	.70	.60	.60	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 3	.....	.....	.....	8.95	9.27	.15	.22	.30	.30	.27	.22	.30	.20	[illegible]
April 4	.....	.....	.....	.....	.....	.....	.....	8.32	.50	.65	.75	.25	.20	[illegible]
April 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 7	.40	.60	.80	3.00	.20	.50	.90	4.10	.40	.70	5.00	.30	.60	[illegible]
April 8	.30	.50	.60	.70	.80	2.10	.40	.70	3.00	.25	.40	.70	4.00	[illegible]
April 9	.25	.20	.30	1.40	.60	.80	.90	2.10	.30	.50	.70	.90	3.10	[illegible]
April 10	.35	.25	.10	1.90	.70	.65	.60	.55	.55	.60	.60	.70	.80	[illegible]
April 11	.....	.....	.....	.....	.....	.....	3.10	.00	2.80	.80	.70	.80	.65	[illegible]
April 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
April 14	.80	.70	.60	.50	.40	.20	.00	6.80	.60	.40	.20	.00	5.80	[illegible]
April 15	.25	.30	.30	.30	.20	.05	7.90	.70	.50	.30	.20	.10	.00	[illegible]

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Tide observations at Five-Mile Point—Continued.

Date.	10.10 a. m.	10.20 a. m.	10.30 a. m.	10.40 a. m.	10.50 a. m.	11 a. m.	11.10 a. m.	11.20 a. m.	11.30 a. m.	11.40 a. m.	11.50 a. m.	12 m.	12.10 p. m.	12.20 p. m.
March 31	.00	4.95	.75	.55	.35	.15	3.90	.75	.65	.45	.30	.15	.00	2.90
April 1	.25	.00	5.80	.65	.40	.30	.10	4.90	.75	.55	.40	.20	.00	3.95
April 2														
April 3	.00	8.85	.70	.50	.27	.02	7.80	.57	.25	6.95	.72	.47	.22	.00
April 4	9.00	8.95	.85	.75	.60	.40	.20	.00	7.77	.52	.30	.10	6.85	.55
April 5		7.40	.60	.70	.50	.40	.50	.50	.40	.20	6.90	.70	.40	.20
April 6							8.70	.70	.80	.80	.80	.75	.65	.50
April 7	6.20	.40	.60	.80	7.00	.10	.50	.70	.90	8.10	.35	.40	.60	.60
April 8	.60	.80	5.10	.40	.70	.90	6.20	.40	.60	.80	7.00	.20	.40	.60
April 9	.50	.70	.90	4.10	.30	.50	.70	5.10	.40	.60	.90	6.20	.40	.60
April 10	.25	.50	.70	.80	3.10	.30	.50	.70	4.00	.20	.40	.70	5.00	.20
April 11	.50	.60	.60	.60	.80	.90	3.00	.20	.45	.60	.80	4.00	.20	.40
April 12				2.50	.30	.25	.30	.35	.40	.50	.60	.70	.80	.90
April 13										2.30	.15	.20	.20	.20
April 14	.30	.10	4.90	.70	.55	.30	.10	3.90	.70	.50	.35	.20	.10	2.90
April 15	.40	.20	.00	5.80	.60	.40	.20	.00	4.80	.60	.30	.10	3.90	.60

Date.	12.30 p. m.	12.40 p. m.	12.50 p. m.	1 p. m.	1.10 p. m.	1.20 p. m.	1.30 p. m.	1.40 p. m.	1.50 p. m.	2 p. m.	2.10 p. m.	2.20 p. m.	2.30 p. m.	2.40 p. m.
March 31	.85	.85	.80	.70	.70	.75	.80	.85						
April 1	.85	.70	.55	.40	.25	.20	.20	.15	.10	.10	.10	.15	.20	.25
April 2											3.30	.20	.00	.00
April 3	5.77	.55	.37	.15	4.85	.60	.37	.15	3.95	.82	.67	.47	.32	.20
April 4	.25	.00	5.80	.55	24	4.97	.70	.47	.20	3.90	.67	.50	.25	.00
April 5	5.90	.70	.40	.20	4.95	.65	.40	.20	.15	3.90	.60	.40	.20	2.90
April 6	.40	.20	.00	7.80	.50	.30	.10	6.90	.50	.20	5.90	.60	.40	.10
April 7	.60	.50	.40	.25										
April 8	.80	.95	8.10	.20	.10	.10	0.5	7.90	.80					
April 9	.80	7.10	.30	.50	.70	.80	.90	8.05	.25	.25	.30	.40	.35	.30
April 10	.40	.60	.90	6.00	.20	.40	.70	.90	7.10	.40	.50	.60	.70	.80
April 11	.70	5.10	.20	.40	.60	.90	6.20	.40	.60	.70	.90	7.10	.25	.40
April 12	3.10	.50	.70	.90	4.20	.40	.60	.90	5.10	.40	.60	.70	.80	6.00
April 13	.20	.25	.30	.40	.50	.70	.90	3.00	.10	.30	.40	.65	.80	4.10
April 14	.70	.60	.50	.45	.45	.40	.35	.40	.45					
April 15	.40	.30	.20	.00	2.90	.80	.70	.60	.50	.40	.40	.40	.40	.50

Date.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.50 p. m.	5 p. m.
March 31														
April 1	.35	.40												
April 2	.00	.00	.00	.05	.10									
April 3	.07	2.95	.85	.77	.72	.70	.70	.75	.85	.97				
April 4	2.80	.62	.45	.30	.15	1.97	.85	.75	.67	.62	.62	.67	.75	
April 5	.70	.40	.20	1.90	.60	.35	.10	0.90	.80	.80	.60	.35	.25	
April 6	4.65	.40	.20	3.95	.65	.40	.10	2.90	.70	.50	.20	.00	1.80	60
April 7														
April 8														
April 9	.20	.10	.00											
April 10	.90	8.00	.05	.00	.00	7.90	.80							
April 11	.60	.80	8.00	.10	.20	.30	.35	.40	.45	.50	.40	.30	.20	
April 12	.10	.20	.40	.60	.80	.90	7.10	.25	.40	.50	.65	.65	.75	.90
April 13	.40	.60	.80	5.00	.20	.40	.60	.80	6.00	.20	.40	.60	.80	7.10
April 14														
April 15	.60													

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Tide observations at Five-Mile Point—Continued.

Date.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.	6.30 p. m.	6.40 p. m.	6.50 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall.
												Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*
March 31												(*)	10	(*)			4.90
April 1												20	20	6 00			4.65
April 2												30	40	6 15			5.60
April 3												20	20	6 40			6.60
April 4												10	0	6 15			7.40
April 5	20	30	40	60	70	90	1.10					0	0	6 30			7.50
April 6	50	40	20	00	20	25	.30	35				20	0	6 00			7.80
April 7												20	20		6 00	7.70	
April 8												0	10		5 55	7.40	
April 9												0	0		6 20	7.20	
April 10												0	10		6 05	6.50	
April 11												10	0		6 20	6.00	
April 12	90	90	90	85	75							20	0		6 15	5.65	
April 13	20	30	40	60	70	80	.90	90	90	85	80	20	30		6 15	5.70	
April 14												20	0	5 40			5.75
April 15												20	30	5 55			5.90

* Not determined.

Expediency of removing light-house at entrance to New Haven Harbor.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, Rhode Island, March 27, 1872.

I have the honor to submit the following report in regard to the expediency of removing the light-house at the entrance to New Haven Harbor, Connecticut, from its present position to Southwest Ledge.

I would recommend that the change be made, for the following reasons:

1st. In approaching the harbor from the eastward the light is not visible until nearly abreast of it, being shut out by woods. In coming from the westward the light is so situated as to render its position very deceptive, making it appear nearer than it actually is; many vessels ground on the west-shore flats from this cause.

2d. If the light-house was on the ledge, vessels could run for it until it was close aboard, then haul to the northward, pass to the westward of the light, and head up the harbor directly for the fixed red light on Long Wharf, thus following the line of best water up the harbor, avoiding all rocks and shoals. The light-house would also serve as an excellent channel-mark by day as well as by night. In consequence of the present position of the light, it is necessary to run by bearings and estimated distances, thus rendering dangerous the entrance to the harbor.

3d. The woods in the vicinity of the present light-house so deaden the sound of the fog-bell that in fogs accompanied by a southerly breeze it is impossible to hear the bell more than six hundred or seven hundred feet, except when directly abreast to the westward of the light. This would be obviated by placing the light-house upon the ledge. Besides thus greatly improving the entrance to the harbor itself, the position of the light on Southwest Ledge would be about one mile farther out in the sound, and would furnish an excellent object for vessels passing along the sound to steer by and correct their positions from in thick weather. New Haven Harbor is much used as a harbor of refuge, and should the light-house be placed on Southwest Ledge, vessels whose captains are not acquainted with the harbor could readily find refuge. The nearest lights are the Falkland Island light, twelve miles to the eastward, and Stratford light, twelve miles to the westward. Every reason that occurs to me justifies the removal of the light to Southwest Ledge. Five-Mile Point should be reserved as a site for a fort. Southwest Ledge has now over it, at mean low water, 7.5 feet, and is composed of granitic rock. The contours of the rock, on a scale of 10 feet to the inch, are shown on a tracing I sent you with my report of December 23, 1871, (H. Ex. Doc., No. 137.)

I return herewith the copy of the resolution sent me.

Yours, respectfully,

G. K. WARREN,
Major Engineers, Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

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IMPROVEMENT OF HOUSATONIC RIVER, CONNECTICUT.

My report dated January 20, 1872, along with the report of Mr. Henry Harding, civil engineer, made to me, both printed as part of House Ex. Doc., No. 137, second session forty-second Congress, gave an account of the condition of this work down to this period. At that time there was an unexpended balance from former appropriations of $3,168.21. The work done in 1871 was not injured by the spring freshets, and the dredging at Mill Bar was resumed in June, during which month 9,008 cubic yards were excavated and removed. A survey of the bar at the mouth of the river was begun in July, and is nearly completed in the field.

Advertisements for proposals to do the work under the appropriation of $15,000, appropriated June 10, 1872, were made on the 28th of June.

The design of this improvement is to give a low-water channel 7 feet deep. The mean rise and fall of the tide is about 4 feet.

(1.) DREDGING BETWEEN DERBY AND HUNTINGTON LANDING.

There is required here an excavation of about 2,500 cubic yards from a bar having now 3½ feet at mean low water. The depth required is 6 feet at mean low water. The material is chiefly sand.

(2.) TWO-MILE ISLAND BAR, ONE MILE BELOW DERBY.

There is required here an excavation of about 16,000 cubic yards of sand. The depth of the water is from 4 to 7 feet at low water.

(3.) CROFUT'S BAR, NEAR WOOSTER ISLAND, TWO AND A HALF MILES BELOW DERBY.

There is required here an excavation of 6,000 cubic yards of sand. The depth at low-water is from 4 to 7 feet.

(4.) DREDGING ON THE BAR AT THE MOUTH.

It may be desirable to remove about 15,000 cubic yards of sand from this place, and proposals are invited. There is about 4 feet at low-water at this place, and it is exposed to the waves of the sound.

(5.) EMBANKMENT AT DREW'S ROCK.

This is to connect this rock with the west shore, and will take about 600 cubic yards of stone, which must be blasted or quarried out, and must be of sizes between ¼ a cubic foot and 10 cubic feet thrown in to take their own bed. A layer of small regular stones or quarry-waste, of at least 6 inches in thickness, must be put on the upstream side, so that it will arrest the sand and gravel. The side slopes are to be 1 to 1, and the top of the embankment is to be 10 feet wide and on a level with high tides.

The lowest bidder for the dredging, Mr. R. M. Jones, of New York, is probably what is called a "*straw-man*," as, after due search, neither he nor his guarantors could be found. The dredging was, therefore, awarded to Francis H. Smith, of New York, the next lowest bidder, at 23.95 cents per cubic yard.

The lowest proposal for building the embankment at Drew's Rock, was Mr. A. A. Bouker, of New York, at $1.70 per cubic yard, and the contract was made with him. Work under it has already begun.

The following is an abstract of the proposals received:

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Abstract of proposals for the improvement of the Housatonic River. Contracts received at the Engineer Office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Price per cubic yard for dredging from Derby to Huntington, about 2,500 cubic yards.	Price per cubic yard for dredging at Two-Mile Island Bar, about 16,000 cubic yards.	Price per cubic yard for dredging at Crofut's Bar, about 6,000 cubic yards.	Price per cubic yard for dredging at the mouth, about 15,000 cubic yards.	Price per cubic yard for embankment at Drew's Rock, about 600 cubic yards.	Commence.	Complete.	Whole amount of dredging, at the price named, would cost, (39,500 cubic yards.)	Six hundred cubic yards of riprap stone would cost—	Remarks.
	Cents.	*Cents.*	*Cents.*	*Cents.*						
R. M. Jones, New York City.....	21. 37	21. 37	21. 37	21. 37	.....	Sept. 1, 1872	June 30, 1873	$8, 441 15	.....	No certificate that guarantors are responsible parties.
Francis H. Smith, 121 Front street, New York City.	23. 95	23. 95	23. 95	23. 95	.....	Aug. 15, 1872	June 30, 1873	9, 457 25	.....	
S. F. Shortland & Bro., 106 Wall street, New York City.	24. 73	24. 73	24. 73	24. 73	.....	Aug. 15, 1872	Soon as practicable.	9, 768 35	.....	No certificate that guarantors are responsible parties.
Morris F. Brainard, Albany, New York.	30	28	28	49¼	.....	April 1, 1873	June 30, 1873	14, 335 00	.....	
H. N. & A. J. Beardsley, Bridgeport, Connecticut.	30	29	28	38	.....	Aug. 10, 1872	Jan. 1, 1873	12, 770 00	.....	
A. A. Bouker, 120 Wall street, New York City.	.....	.....	.....	.....	$1 70	Aug. 15, 1872	June 30, 1873	.....	$1, 020 00	
E. A. Wentworth and John F. Sheak, Derby, Connecticut.	.....	.....	.....	.....	*1 74	.....	.....	.....	1, 044 00	Guarantee not in duplicate. No witness to signatures of guarantors. No certificate that guarantors are responsible parties.

* Measured in embankment.

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There is some dredging to be done above Derby not estimated in the original survey, the exact amount of which is not yet ascertained, and considerable is required at the bar at the mouth of the river, to be determined by the survey now making, in addition to what has been heretofore estimated for. I therefore recommend an appropriation of $20,000 for the work during the fiscal year ending June 30, 1874.

The very large water-power now available at the new dam across the Housatonic River promises a great increase in the freighting on the river and renders it a navigable stream of importance.

The New York and New Haven Railroad Company have constructed an excellent drawbridge across it; but the wagon-road bridge put below it is an unnecessary obstruction, and something must be done to abate it.

The Housatonic River is the boundary between the New Haven and Fairfield collection districts, and Bridgeport is the nearest port of entry. The amount of revenue collected during the fiscal year ending June 30, 1872, at Bridgeport was $4,616.50, and at New Haven $222,065.36.

For the details of last season's work I refer to the annexed reports by myself and Mr. Harding:

Statement of funds.

Amount available July 1, 1871	$14,676 70
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during fiscal year ending June 30, 1872	13,751 81
Amount available July 1, 1872	15,924 89
Amount required for the fiscal year ending June 30, 1874	20,000 00

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, January 20, 1872.

GENERAL: I have the honor to make the following report of the operations of improving the Housatonic River, Connecticut, during the past season:

The condition of this work at the date of my last annual report, August 31, is given in your printed annual report for 1871, (pp. 777, 778, 779.)

The work continued in progress till the autumn weather compelled us to desist. The improvement, consisting of a riprap embankment at Sow and Pigs Rocks, was completed. A channel 80 feet wide and 7 feet deep was dredged through Drew's Bar, and a channel 42 feet wide and 7 feet deep was excavated through Mill Bar. These depths are at mean low water. Surveys were also made in addition to the previous ones. The expenditures have been as follows:

For riprap embankment at Sow and Pigs Rocks, 778.34 cubic yards, at $1 90	$1,478 84
For dredging at Drew's Bar, 28,922.41 cubic yards, at 18 cents	5,206 03
For dredging at Mill Bar, 9,447.85 cubic yards, at 18 cents	1,700 61
For engineering and incidental expenses	3,446 31
Balance on hand December 31	3,168 21
	15,000 00

An additional appropriation of $15,000 has been asked for.

Along with this report I transmit the report of Mr. Henry Harding, civil engineer, who superintended the execution of the work, which gives all the details deemed desirable. Mr. Harding's report is accompanied by four maps, one being of the work at Sow and Pigs Rocks, another of the dredging at Drew's Bar, another of the detailed survey of Drew's Rock, and the other of the dredging done at Mill Bar. These maps of the bars where dredging was done are colored, so as to show the monthly progress of the work.

The original survey was made by Captain W. S. Edwards, civil engineer, but the locations of the improvements were made by General T. G. Ellis, civil engineer.

Yours, respectfully,

G. K. WARREN,
Major Engineers and Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers United States Army,
Washington, D. C.

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NEWPORT, RHODE ISLAND, *January* 1, 1872.

GENERAL: I have the honor to submit the following final report of operations for the season ended November 29, 1871, for the improvement of Housatonic River, Connecticut, conducted in accordance with section 1 of the appropriation act for rivers and harbors, approved March 3, 1871. The amount of the appropriation was $15,000.

The navigable portion of the Housatonic River (heretofore only so at high water) is about thirteen miles in length from the sound to Derby, at which point there are two other thriving towns, Huntington and Ansonia, the latter about a mile north, and situated on the Naugatuck River, which flows into the Housatonic River at Derby. These towns are of growing importance, and already carry on a large freighting business by the river. This is attended by a considerable delay and expense, as they are often compelled to lighten their barges at Bridgeport, having to make two trips from that place, where, if the river was improved, but one would be necessary. Heretofore much of the material used in the manufacturing at these places has been carried by railroads, which would have come by river, had not the navigation been so difficult.

Drew's Bar was the first point where the improvement commenced, and was that of dredging, which was begun July 18, 1871, by P. W. Myers, contractor for the above, as also all other work done at the two other points on the river, (Sow and Pigs Reef and Mill Bar.) The dredging was done with an Osgood dredge.

The object at this point (Drew's Bar) was to connect the deep waters of the two separate channels above and below the bar. When the improvement was commenced the design was to remove Drew's Rock, as it is located in the channel usually navigated: further surveys, however, showed that the cost of removing it would be far more than the cost of an embankment from it to the shore. Estimates for the removal of this rock and for an embankment will be found further on. It was first proposed to make a channel 1,540 feet long, 100 feet wide, and 7 feet deep at mean low water. This was done, with exception of the width of the channel, which was left at 80 feet, in order to make the necessary improvement at Mill Bar this season. Below Drew's Rock it was deemed necessary to make one cut of 20 feet wide, so as to enable vessels to keep more to the eastward coming up to the rock. This makes an addition to the above distance of 440 feet.

Total amount excavated during the season at the above points, 28,922.41 cubic yards. I do not think that it will be necessary to do any more dredging at this point the coming season. Work at this point was finished the 23d of October, 1871.

While the work was going on at Drew's Bar, according to your order, I made a survey and soundings at Sow and Pigs Reef and laid out the work for the wing-dam, which was also built during the time that the contractor was at work at Drew's Bar.

The total length of the dam from the initial point on Sow and Pigs Reef to high-water mark on east shore is 163 feet; width on top, 10 feet, and a slope on both up and down stream sides of 1 to 1. The up-stream slope has a layer of quarry waste exceeding 6 inches in depth over its entire surface, so as to render it impervious to both sand and gravel.

Total number of cubic yards of stone in dam is 778.34. The object of this dam is to obviate various difficulties to navigation at this point. Its design is not so much to increase the depth opposite (or the river's cross-section) as to render the safe passage of vessels going down stream. Heretofore, when vessels would near that portion of the river, they experienced great difficulty in overcoming that point, from the danger of being drawn on or against the rock by the force of the body of the current at that point passing between the rock and the east bank, which opening was not practicable for vessels.

Although but limited observations have been made since the construction of the dam, I think it safe to say that this one serious impediment is already overcome. The position of the dam is not at right angles with the thread of the stream, or, in other words, is not exactly in the line of the transverse section. This location was considered advisable on account of the solid rock on the east bank for the dam to bed against, therefore obviating any danger of washing around the shore end. This position was selected by General Ellis and approved by you.

Mill Bar was the next and last point of improvement on the river, and was but partially completed. This work was commenced the 23d of October, 1871. The nature of the work was dredging in sand, so as to give a 7-foot channel at mean low water, otherwise opening the old channel to a width of 150 feet, and to connect the north and south deep-water channels. This is done at present to a width of only 42 feet, and in length a distance of 750 feet. The amount dredged at this point is 9,447.85 cubic yards. This does not seem to be the river's natural channel, inasmuch as it is out of direction of the main body of water in coming down stream, although it has been the main sailing-track since 1864, and is doubtless the most feasible as regards expense.

The old channel, navigated previous to 1864, has a serious obstruction opposite the mouth of the stream leading out of the Mill Pond, consisting of a rock 3 feet under water at mean low water.

I would here suggest that, in further prosecution of the work at this point, the

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dredging in the upper portion of the canal shall be done on the east side of where the work has already been done, but in the south portion continue from the sand island down, as at present laid out.

I find from observation that there is a cross-current which causes the sand, so that it deposits on the island and its vicinity, (therefore cutting into the island, as this present lay-out does.) The liability would be that of soon filling up; therefore the suggestion of moving eastward, so as to overcome the above difficulty. The cutting is even heavier than indicated on the map; that is, that portion which begins at the sand island, thence north.

During the prosecution of the work at Mill Bar, I made a survey and soundings at Drew's Rock, according to your directions. I have made an approximate estimate in reference to its removal. The number of cubic yards to be removed, to give 7 feet at mean low water, is about 419; at $15 per cubic yard, would amount to $6,285.

I have also made an approximate estimate for a wing-dam at the same point, of the following dimensions: 123 feet long, 10 feet wide on top, with a slope of 1 to 1 on both the up and down stream sides, and to extend to mean high water the entire length. The amount of stone required would not far exceed 330 cubic yards, and cost, at $1.90, (price paid for same kind of work this season,) would amount to $627.

This dam to run from the west bank to rock, starting from the shore at a point far enough below the rock, so as to make an angle of 70° with the bank and stream.

Recapitulation of work done on Housatonic River during the season.

Dredging 38,370.26 cubic yards, at 18 cents		$6,906 64
Wing-dam, 778.34 cubic yards, at $1.90		1,478 84
		8,385 48
Engineering and incidental expenses		3,446 31
Total amount expended		11,831 79
Amount of appropriation for improvement	$15,000 00	
Total amount expended	11,831 79	
Balance remaining		3,168 21

Accompanying this report will be found maps, as follows: Map of Sow and Pigs Rocks, (or Reef,) containing the survey of the above point, plan, and position of dam, with cross and longitudinal section of same; scale of map, 30 feet to 1 inch. Maps of Drew's Bar and Mill Bar, on scale of 24 inches to the mile, or 220 feet to 1 inch. These maps show the progress of work during each month, and is indicated as shown by color. Map of survey of Drew's Rock, (1871,) scale 10 feet to 1 inch.

Very respectfully,

HENRY HARDING.

Brevet Major-General G. K. WARREN,
Major of Engineers, United States Army,
Newport, Rhode Island.

T 10.

IMPROVEMENT OF BRIDGEPORT HARBOR, CONNECTICUT.

The appropriation of $20,000, approved March 3, 1871, was all expended, in the manner proposed in my last annual report, by the end of that year, in December. With this appropriation, preparatory to going to work, a careful survey and map of the bar were made. The result of this was to confirm me in the opinion that no great permanent increase of depth could be secured by dredging on the bars, until works were constructed to prevent the drift of the sand across the entrance, as it is moved by the waves along the shores of the sound.

The depth on the outer bar was found to be substantially the same as

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when Lieutenant Blake, United States Navy, made his survey in 1837, viz, 6 feet at mean low water, to which plane the soundings made under my directions have been reduced, or 5 feet at mean low water of spring tides, which is the plane to which Blake reduced all his soundings.

The dredging was therefore only made now as a temporary relief, and only to the extent which this justified.

Three prominent shoals were thus worked upon.

The digging was carried much deeper than the rest of the channel, so that if the excavations fill up again, more time will be required to do it. We thus removed from the channel-way on the

Outer bar, 3,020 cubic yards, at 23$\frac{4}{10}$ cents	$706 68
Inner bar, 10,280 cubic yards, at 23$\frac{4}{10}$ cents	2,405 52
Opposite Cook's Point, 11,194 cubic yards, at 23$\frac{4}{10}$ cents	2,619 40
	5,731 60

I have been informed that a vessel drawing 7½ feet came in on November 11, at a very low tide—2 feet below the mean low tide.

The riprap breakwater has been built out from Long Beach a distance of 521 feet. It rises about 2 feet above high water of spring tides, has an isosceles triangle for its cross-section, each side sloping 45°. It has so far taken 3,924 tons of stone at a cost of $2.84 per ton, and a total of $11,144.16.

The thorough survey and map have been made only by a considerable expenditure, and the appropriation of $20,000, approved March 3, 1871, is entirely exhausted. I therefore renew the recommendation for an additional appropriation, made in the last annual report.

The map is about done. I send herewith a tracing from it, showing the location of the work done the past year, and also a detailed report of the dredging operations, made by Captain W. S. Edwards, civil engineer.

I conclude this report with a few remarks on the drifting of materials along the shores of the sound. The coarseness of this material on the shore depends upon quality of the material at the place it was derived, and upon the distance which it has been moved by the waves and tide. On the north shores of the sound the headlands are composed frequently, and on the south side always, of accumulations of the glacial period, consisting of large and small bowlders, and diminishing in size down to pebbles, sand and clay.

These headlands are being continually abraded (as there is evidence that the shores are gradually sinking) by the waves. The clay mingles with the water and is borne away to great distances, and deposited often at the greatest depths.

The sand, at ordinary times, is kept in motion by the rise and fall of the waves, and their general motion being westward in Long Island Sound, the resultant is, with occasional intermissions, a progress of the sand westward. This action takes place between the high-water line and the line of depth which limits the action of the wave. In heavy storms, stones of a foot in diameter are also thus moved along the shore. The large bowlders, in all cases, remain at the foot of the abraded hill from which they fell, but have in few cases, if any, accumulated in sufficient quantity to stop the further abrasion of the headlands by the waves. The supply is thus kept up and the drifting is constantly going on. Examinations at all the points of Long Island shores show this movement to be to the westward, and it must be everywhere, even if there seems to be no perceptible change in the entrance to any particular

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harbor, and it must therefore be going on across the harbor of Bridgeport. The constant depth on the outer bar of this harbor, since the survey of Blake in 1837, being maintained by the equilibrium existing between the sand thus brought into the harbor-channel by the shore-drift and the scour of the ebb-tide out of the inclosed harbor, any diminution of interior space, by filling in of this inside harbor to any extent, must diminish the amount of water flowing in and out, and have the effect to diminish the depth at the entrance, and anything which shall increase the action of the ebb-tide must deepen the entrance. Further, if by any means we can arrest this motion of material along the shore, we shall also tend to increase the relative power of the ebb-tide, and consequently the depth.

It is with this view, but not without meeting opposite opinions from some as well as support from others, that I have projected the jettee on the south side of the entrance. I believe it is a law of this littoral wave and current action to move the heaviest material along the line of mean low water, and that the material diminishes in size as the depth increases.

Thus, then, a jettee begun from the shore and pushed beyond the low-water line begins to arrest the coarser material at once, so that the finer material only passes on to the entrance of the channel, and upon this the action of the ebb-tide is more powerful than on the coarser deposits, and will maintain a greater depth. The farther out the jettee is pushed the more it intercepts the material, and thus reduces the obstruction to the tide; and the more it contracts the entrance the more it increases the action of the tide upon it. I have as yet estimated only for a jettee on the east side of the harbor; but one on the west side may also be necessary to intercept the occasional eastward movement of the sands, and more particularly to further confine the action of the ebb-tide scour. The effect of the jettees will, I think, be to prevent the formation of the inner bar, after they are completed. These bars, as they at present exist, seem to be due to the opposing effects of the scour of the ebb and flood tides, causing two principal points in the entrance at which the littoral sands make their transit across the harbor.

Viewed by itself, one might not readily admit the principles I have laid down from the action exhibited at Bridgeport Harbor. But just across the sound, at Port Jefferson, we have all the phenomena resulting from the action of the waves exhibited in a more intense manner. The size of the waves of the sound, and the rise and fall of the tide, are almost the same. But whereas at Bridgeport there is no headland to the east of it to supply anything but sand and a little gravel, there is, just east of Port Jefferson Harbor, distant only 4,000 feet, the Mount Misery Point, which is being greatly abraded, supplies all classes of drift-material, and especially abounds in pebbles and large paving-stones. The lodgment of these paving-stones directly across the inclosed harbor of Port Jefferson has been so firmly made and persistently kept up that there is a narrow entrance of only 310 feet in width, with a depth on the bar of only half the depth at Bridgeport, though the scour of the tide, owing to the greater inclosed space and narrow entrance, is vastly more, amounting sometimes to a velocity, due to a fall of 2 feet, of as much as 10 feet per second.

The accumulation of these stones on the east side has caused the entire entrance and channel-way to move westward a distance, since 1838, of 790 feet, or $\frac{790}{33}=24$ feet a year. If this rate is constant, it was only about a century ago when the entrance was at the west side of Mount Misery Point. It will, if not arrested, keep on moving westward until some barrier is reached, when the sea will probably break through again

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near Mount Misery, which it already shows a tendency to do, and then this movement will repeat itself.

It is very obvious from this statement of Port Jefferson entrance, that a channel dredged out there, without any jettee on the east side, would fill up completely in a year to a depth of at least 3 feet, over a width of not less than 24 feet, the present rate of the advance of the east sand-spit. Now if we go back to Bridgeport, remembering that the waves and tides of the sound are the same, and the power on the shore not materially less, we can see what immense force is exerted in transporting material across its entrance, and though the supply of material is different, we see how very probable it is that our dredged channel will be filled up by the shore material which will drift across it. The importance, then, of taking some action to arrest the sand and increase the scour of the tide is obvious.

The act of Congress approved June 10, 1872, appropriated $40,000 for continuing this work during the fiscal year ending June 30, 1873. On the 28th of June advertisements were issued for doing the work, according to the following specifications:

For continuing the breakwater there are required 8,000 tons of riprap granite in blocks averaging not less than 1½ tons each, and none weighing less than one-fourth of a ton. They should be as nearly cubical as practicable, the smallest dimension not less than one-third the greatest.

The breakwater is to be triangular in cross-section, with side slopes 45°, and is to be built to the level of high water. It is now completed out to near low-water mark. The tide rises 7.6 feet.

The stone can be deposited in the work from the deck of vessels with a common spar-derrick.

The place is exposed to the waves of the sound in southerly winds.

Dredging will be required in the outer bar, inner bar, and between the inner bar and the wharves. The amount set aside for this work is $10,000.

The work will be done at the different places, as the necessities of the case may require. The material to be dredged is mostly sand.

Dredging on the outer and inner bars can be done only when there are no waves.

The dredged material can be deposited within one-half a mile outside of the outer bar.

Proposals for furnishing stone will state the price per ton placed in the work: for dredging, the price per cubic yard, measured in the scows.

The following is an abstract of proposals received:

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Abstract of proposals for the improvement of Bridgeport Harbor, Connecticut, received at the engineer office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Granite—price per ton.	Dredging—price per cubic yard.	Commence—	Complete—	Amount of granite bid for.	Granite will cost at price named—	Balance available for dredging will remove—	Remarks.
		Cents.			*Tons.*		*Cub. yds.*	
D. V. Howell, 141 Chambers street, New York City.	$2 37	.....	Sept. 1, 1872	June 30, 1873	8,000	$18,960	.....	
George H. Platt, Brooklyn, Long Island, New York.	2 44	.....	Sept. 8, 1872	July 1, 1873	8,000	19,520	.....	No certificate that the guarantors are responsible parties.
Andrew W. McKee, Huntington, Long Island, New York.	2 62½	.....	Aug. 20, 1872	June 30, 1873	8,000	21,000	.....	Proposals for this work, Huntington Harbor, Long Island, New York, and Port Jefferson Harbor, Long Island, New York, made out on one blank.
John Beattie, Stony Creek, Connecticut.	2 67	.....	Aug. 10, 1872	April 10, 1873	8,000	21,360	.....	No witness to signature of guarantors.
J. H. McCormick, 99 Maiden Lane, New York City.	2 73	.....	Sept. 1, 1872	July 1, 1873	8,000	21,840	.....	No witness to signature of guarantors, and no certificate that guarantors are responsible parties.
Dawson, Tank & Co., New London, Connecticut.	2 74	.....	.....do	June 30, 1873	2,000	5,480	.....	
C. W. Campbell & Co., Lyme, Connecticut.	2 84	.....	Aug. 15, 1872	.....do	8,000	22,720	.....	
Andrew A. Bouker, 120 Wall street, New York City.	2 95	.....	.....do	Last of June.	4,000	11,800	.....	
C. C. Campbell, Lyme, Connecticut	2 99	.....	Aug. 20, 1872	June 30, 1873	4,000	11,960	.....	
Sidney F. Shelbourne, 11 Gold street, New York City.	.....	21 7-8	At once	.....do	.....	.....	96,182	No certificate that guarantors are responsible parties.
L. Morton, Mechanics' Exchange, Brooklyn, Long Island, New York.	.....	24 4-10	Sept. 7, 1872	Dec. 1, 1872	.....	.....	86,229	No witness to signature of guarantors, and no certificate that they are responsible parties.
Francis H. Smith, 121 Front street, New York City	2 89 3 29	28 4-10	Aug. 15, 1872 .....do	June 30, 1873 .....do	4,000 4,000	11,560 13,160	74,084	
H. N. & A. J. Beardsley, Bridgeport, Connecticut.....	.....	Cook's bar, 17 Stony bar, 24 Outer bar, 28 1-2	Aug. 10, 1872 .....do ....do	Jan. 1, 1873 .....do ....do	.....	.....	*90,818	
S. F. Shortland & Brother, 106 Wall street, New York City.	.....	29	Aug. 15, 1872	As soon as practicable.	.....	.....	72,552	No certificate that guarantors are responsible parties.

* In figuring these, it is assumed that an equal amount of dredging will be done at each place named.

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The lowest bidder for the riprap being Mr. D. V. Howell, of New York City, the contract for it was awarded to him. Mr. S. F. Shelbourne, of New York City, was awarded the contract for dredging, he being the lowest bidder for that work. The last appropriation will all be expended during the current fiscal year, and on account of the importance of this harbor I recommend an appropriation of $60,000 for continuing the work during the fiscal year ending June 30, 1874.

Bridgeport is in the Fairfield collection-district, and is a port of entry. The amount of revenue collected during the fiscal year ended June 30, 1872, was $4,616.50.

Statement of funds.

Amount available July 1, 1871	$17,954 1[illegible]
Amount appropriated by act of June 10, 1872	40,000 [illegible]
Amount expended during fiscal year ending June 30, 1872	17,952 [illegible]
Amount available July 1, 1872	40,001 [illegible]
Amount required for fiscal year ending June 30, 1874	60,000 [illegible]

T 11.

IMPROVEMENT OF WESTPORT HARBOR, CONNECTICUT.

There was no new appropriation made for continuing this work during the fiscal year ended June 30, 1872, nor for the fiscal year ending June 30, 1873. But an unexpended balance of former appropriations, amounting to about $2,300, was available, and as it was too little to attempt any improvement heretofore recommended, and as there was much need of a careful survey, and more exact information as to the condition of the harbor, I directed such survey to be made.

This was completed in May and June in the field, and the map is nearly made. A special report in regard to this work will be made the next winter. I therefore make no recommendation at this time for further appropriation.

Westport is in the Fairfield collection-district, the nearest port of entry being Bridgeport, Connecticut. The revenue collected there during the fiscal year ended June 30, 1872, was $4,616.50.

Statement of funds.

Amount available July 1, 1871	$2,67[illegible]
Amount expended during fiscal year ending June 30, 1872	2,0[illegible]
Amount available July 1, 1872	641 [illegible]

T 12.

SURVEY AND IMPROVEMENT OF NORWALK HARBOR, CONNECTICUT

This survey, duly authorized, was made during the season in the first part of the last fiscal year. The reports of it were made December 16, 1871, and printed as part of Senate Ex. Doc. No. 23, second session, Forty-second Congress, and are appended to this report.

The act approved June 10, 1872, appropriated $10,000 for this work during the current fiscal year. On the 28th of June advertisement was made for doing the work according to the following specification:

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BETWEEN THE RAILROAD-BRIDGE AND THE STONE BRIDGE.

Dredging.—This is to commence in the channel opposite W. Jennings's wharf, and extend up to the stone bridge, making a channel 60 feet wide and 6 feet deep at mean low water. The material to be dredged is mud, sand, and gravel, in the order named as you go up stream. It will have to be dumped outside of the mouth, at an average distance of two and one-half miles. The depth of water on that part of the river where dredging is to be done is from 1 foot to 3 feet. The tide rises 7.1 feet.

Proposals must state the price per yard at which the work will be done.

Mr. G. H. Ferris, of Brooklyn, New York, being the lowest bidder, the contract was awarded to him.

The following is an abstract of the proposals received:

Abstract of proposals for the improvement of Norwalk River, Connecticut, received at the engineer office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Price per cubic yard of material dredged.	Commence—	Complete—	The amount appropriated would remove, at price named—
	Cents.			*Cubic yds.*
G. H. Ferris, Brooklyn, New York	24½	Sept. 1, 1872	July 1, 1873	40,816
W. M. Tebo, 77 Woodhull street, Brooklyn, New York	28	Aug. 10, 1872	Nov. 1, 1872	35,714
H. N. & A. J. Beardsley, Bridgeport, Connecticut	29½	Aug. 10, 1872	Jan. 1, 1873	33,898
Morris & Cummings, New York, New York	30	Sept. 1, 1872	Dec. 1, 1872	33,333
Morris F. Brainard, Albany, New York	50	Apr. 15, 1873	June 30, 1873	20,000

The original estimate for this work was $34,000, of which $10,000 has been appropriated. I therefore recommend an appropriation of $20,000 for the fiscal year ending June 30, 1874.

Norwalk is in the Fairfield collection-district, and the nearest port of entry is Bridgeport. The revenue collected there during the fiscal year ending June 30, 1872, was $4,616.50.

The following are the reports of the survey:

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, December 16, 1871.

GENERAL: I have the honor to send herewith the map and report of the survey of Norwalk River, Connecticut, made in obedience to your orders, as authorized by section 3 of the act of Congress making appropriations for the improvement of rivers and harbors, &c., approved March 3, 1871. I send with it a copy of the United States Coast-Survey chart of Norwalk Harbor and approaches, (scale $\frac{1}{10000}$) constructed from the hydrographic survey made in 1835. The soundings on this are reduced to the plane of mean low water of spring tides, which plane is about 6 inches below the mean low-water plane.

The survey made this last summer under my directions was in charge of Mr. J. H. Dager, civil engineer, and his report is annexed to mine. The map is made on scale of $\frac{1}{2500}$, and the soundings are reduced to the mean low water plane.

There are at present about 5 feet at mean low water on the bar at the mouth of the river, and the mean rise of the tide is about 7 feet. The mean rise of spring tide is about 6 inches higher. At Norwalk there is scarcely any water in the channel at low water, and vessels reaching there depend upon tide altogether for the draught brought up to the stone bridge, a distance of about three miles from the mouth. It is proposed to deepen the channel to 6 feet at mean low tide by dredging, and to make it 100 feet wide on the bottom, with side slopes of 45°. The material is mostly mud, except about 1,000 feet of the upper part of the required channel, where there is a coarse gravel. It will have to be all towed in scows out of the river, an average distance of two miles, and dumped there.

The amount to be removed is 153,879 cubic yards, estimated to cost 20 cents per cubic yard, and, allowing for superintendence, it will require in round numbers $34,000. It would be more economical to have all the money appropriated at once than in portions at a time.

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I refer to Mr. Dager's report for further details, and to the papers accompanying it for information regarding the general business on Norwalk River and the importance of the improvement.

The river is in the Fairfield collection-district, and the nearest port of entry is Bridgeport.

The revenue collected at Bridgeport during the fiscal year ended June 30, 1871 amounted to $7,193.96.

Yours, respectfully,

G. K. WARREN,
Major Engineers, and Brevet Major-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, November 20, 1871

GENERAL: I have the honor to submit the following report on the survey of Norwalk River, Connecticut, made in accordance with instructions received from you, dated July 22, 1871.

From a preliminary examination of the river, and a conference with the people in the vicinity interested in its improvement, I learned that dredging, so far as to give an increased depth of water in the natural channel-way, was the only thing desirable, and it is the opinion of those most familiar with the river that if thus deepened it will not be likely to fill up again for a great length of time.

The map I have made is drawn to a scale of $\frac{1}{2500}$. Contours of planes of 0, 2, 4, and 6 feet are shown by black dotted, full blue, red, and green lines, respectively.

A profile of the center line of the proposed channel is drawn to a scale of $\frac{1}{2500}$ horizontally and $\frac{1}{400}$ vertically. The soundings are expressed in feet and tenths and are reduced to the plane of mean low water. Mean low water at the New York and New Haven Railroad-bridge is 22,833 feet below the water-table at southwest corner of Norwalk lock-factory.

Tide-readings were taken every fifteen minutes, day and night, for twenty-one days for the establishment of mean low water but one-half a lunation was used.

The mean rise and fall of the tide is 7.12 feet. The present depth at low water is scarcely 1 foot at Norwalk.

The improvement sought by the people interested in the navigation of Norwalk River is to make a channel 100 feet wide and 6 feet deep at mean low water. This will require dredging to be done from a point about 500 yards above Gregory's Point to the stone bridge at Norwalk, a distance of about two and three-quarter miles.

The depth at present at mean low water on the bar before entering the river is no more than 5 feet, and at mean high water about 12 feet, but in the improvement it is desirable to have something more than 5 feet at mean low water in the river, so that loaded vessels can leave Norwalk before the time of high tide, drawing all the water on the bar, and pass over it before it has sensibly fallen.

The tide is about fifteen minutes earlier on the bar than at Norwalk. At the period of high and low water it is practically at a stand for an hour, not changing its level more than two or three inches in all that time, as can be seen by the tide-observations annexed. Giving the depth of 6 feet at mean low water, seems ample in this case to allow for any vessel using ordinary dispatch to leave the wharves and pass the bar at the most favorable time, loaded to the full draught on the bar.

The material to be dredged is soft mud, except for a distance of about 1,000 feet in the extreme upper part, where it is a coarse gravel. It must be towed in scows an average distance of two miles, and dumped entirely outside of the river.

To make the proposed channel 6 feet deep at mean low water, 100 feet wide at bottom, with sides sloping 45°, will require the dredging and removing of 153,479 cubic yards, estimated to cost 20 cents per cubic yard—$30,775.80; or, allowing for superintendence, &c., will require, in round numbers, $34,000.

The removal of a bed of bowlders (shown in map) will be of particular advantage to vessels engaged in the oyster-trade, as said bed lies immediately in front of the oyster-wharves. This could be accomplished for $1,000, and is not included in the foregoing estimate.

The history of Norwalk and its general business you will find given in an extract from Webb's Northeastern Gazetteer, which I have appended.

The region supplied by the Danbury and Norwalk Railroad, which has its southern terminus at Norwalk, comprises an area of two hundred and forty square miles. This railroad, in connection with the New York and New Haven Railroad and its feeders gives Norwalk business facilities that tend to make it a prominent and prosperous city.

Within eighteen months the Danbury and Norwalk Railroad Company have also

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doned their old wharf in the upper part of the river and constructed a new one above the railroad-bridge, expending from $100,000 to $150,000 making the change. This change was made in consequence of the river becoming so shoal that vessels freighted for them could not land at their wharf and unload without first being lightered.

I append to this report a tide-table, compiled from gauge-readings taken at the New York and New Haven Railroad bridge; another compiled from readings taken at Smith's wharf, and another from readings taken at Gregory's Point. I also append a report of the amount of merchandise received at Norwalk and South Norwalk, and a list of the number of vessels owned at and running to and from Norwalk. Also, a statement of the class and value of the different manufactures of Norwalk, compiled by the Hon. W. C. Street. Also, a copy of the resolution passed by the general assembly of Connecticut in May, 1867, incorporating the Norwalk Harbor Improvement Company. Also, a statement prepared by the draw-tender of the draw-bridge of the New York and New Haven Railroad, giving the number and class of vessels for which the draw was opened during the year 1870, and also for three months of 1871.

In the present condition of the channel only very light-draught vessels can get to the upper part of the river, causing a great deal of annoyance to the business interests of the town. The case seems to merit the favorable consideration of Congress.

The time occupied in making the survey was three weeks, and it extended along the river for three miles. I was assisted in this work by Lewis S. Chase, civil engineer.

I am, general, your obedient servant.

JOHN H. DAGER,
Civil Engineer.

Brevet Major-General G. K. WARREN,
Major of Engineers, U. S. A.

Statement of coal, lumber, plaster, and other merchandise received at Norwalk by tide-water, including amount consigned to the Danbury and Norwalk Railroad.

40,000 tons of American coal.
1,500 tons of English coal.
25,000 tons of lumber, including eastern and western.
31,000 tons of merchandise.
3,000 tons of stone and plaster.
3,000 tons of clay and wood for potteries.
2,000 tons of brick.

Amount landed at South Norwalk.

15,000 tons American coal.
12,000 tons lumber.
1,000 tons pig-iron.
8,000 tons merchandise.
2,000 tons brick.
1,000 tons stone.

Vessels, steamers, &c.

1 passenger-steamer daily to and from New York.
2 propellers daily to and from New York.
20 coal, lumber, and other vessels, owned and running here.

The region supplied by the Danbury and Norwalk Railroad is 30 by 8 miles, making 240 square miles.

Statement of manufacturing interests in Norwalk, not including region supplied by Danbury and Norwalk Railroad.

3 woolen mills, broadcloths; amount of sales per annum, as per statement	$3,100,000
1 wood-turning, sales	50,000
10 shoe, (small and large,) sales	400,000
2 foundries	75,000
2 potteries	65,000
6 carriage-manufactories	75,000
1 shirt-manufactory	1,500,000
1 straw-hat manufactory	500,000
Other small manufactories	200,000

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1 lock-manufacturing company	[illegible]
2 hat-forming manufactories	[illegible]
1 engine-pump manufactory	[illegible]
1 hat-manufactory	[illegible]
Total	7,[illegible]

The amount supplied by the Danbury and Norwalk Railroad will exceed in [illegible] and quantity above for Norwalk.

JOHN H. DAGER: In answer to your inquiries, I send you the foregoing.

Yours, truly,

W. C. STREET.

Resolution formed by the general assembly of the State of Connecticut at its May [illegible] 1867, incorporating the Norwalk Harbor Improvement Company.

Resolved by this assembly:

SECTION 1. That William K. James, A. H. Byington, Samuel E. Olmstead, Will[illegible] S. Lockwood, Edwin Lockwood, Samuel Lynes, John W. Bacon, Ebenezer Hill, Henr[illegible] J. Hoyt, George G. Bishop, William C. Street, J. K. Hubbell, Jonathan Camp, Le[illegible] Lockwood, and Stiles Curtis, together with such other persons as may hereafter asso[illegible]ciate with them, and they are hereby incorporated and made a body politic and cor[illegible]porate, by the name of "The Norwalk Harbor Improvement Company," and by the[illegible] name shall be, and are hereby, made capable in law to have, purchase, receive, pos[illegible] and enjoy, to themselves and their successors, real and personal estate of every kin[illegible] to an amount not exceeding one hundred thousand dollars; and the same, or any par[illegible] thereof, may sell, grant, and alien, may sue and be sued, plead and be impleaded in[illegible] courts whatever, and may do and execute all acts and things to them appertaining[illegible] their said corporate capacity.

* * * * * * *

SEC. 7. The business of said company shall be to improve the harbor at Norwal[illegible] from "the bridge," so called, in the borough of Norwalk, to the bridge of the New Lon[illegible] and New Haven Railroad Company across said harbor. And to that end said corpora[illegible]tion shall have power to straighten and deepen a channel of said harbor in any and a[illegible] places between said two bridges, and may enter upon and take lands for that purpos[illegible] between the Danbury and Norwalk Railroad-track in said channel, in the manner an[illegible] subject to the limitations provided in the charter of the borough of Norwalk and th[illegible] additions thereto, for the taking of lands for highway purposes.

SEC. 8. The said corporation shall have power, in a manner provided in the last pre[illegible]ceding section, to make a new channel for said harbor, and to take lands as aforesa[illegible] for that purpose, at any place or places between said two bridges, and between th[illegible] track of the Danbury and Norwalk Railroad Company and the present channel, an[illegible] to collect tolls upon vessels passing through said new channel, at a rate not exceedi[illegible] five cents per ton on the tonnage of such vessels.

* * * * * * *

Approved June 28, 1867.

Mr. D. Dibble, the draw-tender of the Washington-street bridge, sends us the fol[illegible]ing report of the number and class of vessels for which this bridge was opened duri[illegible] the year 1870:

Months.	Steamers.	Schooners.	Sloops.	Barges.	Sail-boa[illegible]
January	28	3	7	[illegible]	[illegible]
February	22	9	10	3	
March	30	6	13	9	[illegible]
April	40	20	32	18	
May	44	22	31	10	
June	47	36	36	12	
July	56	33	37	21	
August	58	45	57	31	
September	60	39	30	27	
October	56	32	43	32	
November	59	33	40	23	
December	42	15	17	10	
	542	293	373	196	

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Mr. D. Dibble has retired from the position of draw-tender at the Washington-street bridge. He sends us a report of the vessels for which the draw was opened during the past three months:

	June.	July.	August.
Steamers	60	52	84
Schooners	61	50	48
Sloops	35	25	25
Barges	38	29	90
Sail-boats	29	100	103
	213	256	350

Total of all 819

J. H. DAGER, *Civil Engineer.*

NORWALK, CONNECTICUT, 1871.

T 13.

SURVEY AND IMPROVEMENT OF HUNTINGTON HARBOR, LONG ISLAND, NEW YORK.

This survey, authorized by section 3 of the act of Congress approved March 3, 1872, was made in the latter part of last season. The reports were made December 16, 1871, and printed as part of Senate Ex. Doc. No. 23, second session Forty-second Congress, and are appended to this report.

The act approved June 10, 1872, appropriated $22,500 for this improvement. On the 28th of June advertisement was made for proposals for doing the work according to the following specifications:

There are to be dredged about 7,000 cubic yards of sand, gravel, pebbles, and some bowlders, at the entrance of the harbor, so as to make a channel 200 feet wide, and 8 feet deep, at mean low water; the present one is 80 feet wide, and 7 feet deep.

In the inner harbor the channel is to be extended up to the public wharf, a distance of about 2,000 feet; this channel is to be 150 feet wide at the bottom, and 8 feet deep at mean low water, requiring the removal of about 104,000 cubic yards. The material to be excavated in this portion is soft mud. It can be deposited on the flats only at high water; at all other times it must be towed out into deep water at a distance of four or five miles. There is only about 1 foot of water over this distance at mean low water. The mean rise and fall of the tide is 7.6 feet.

Proposals will state the price per cubic yard, measured in the scows, for excavating at each of the two places.

Mr. Sidney F. Shelbourne, of New York, being the lowest bidder, the contract was awarded to him.

The following is an abstract of the bids received:

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Abstract of proposals for the improvement of Huntington Harbor, Long Island, New York, received at the engineer office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Price per cubic yard for dredging at the entrance of harbor.	Price per cubic yard for dredging in the inner harbor.	Commence—	Complete—	The amount estimated to be removed at the entrance is 7,000 cubic yards, and in inner harbor is 104,000 cubic yards, which, at the price named, would cost—	Remarks.
	Cents.	*Cents.*				
H. N. & A. J. Beardsley, Bridgeport, Connecticut.	17	17	Aug. 10, 1872	Jan. 1, 1873	$18,870 00	
L. E. Home, Boston, Massachusetts.....	23	23	Sept. 1, 1872	Last of June, 1873.	25,530 00	104,000 } cubic yards. No witness to signatures of guarantors; no 7,000 } certificate that guarantors are responsible parties.
S. F. Shortland & Bro., Brooklyn, Long Island.	24.73	24.73	Aug. 15, 1872	As soon as practicable.	27,450 30	No witness to signatures of guarantors.
Francis H. Smith, 121 Front street, New York City.	25.94	25.94	Aug. 15, 1872	June 30, 1873	28,793 40	
Andrew McKee, Huntington, Long Island.	29.9	22.25	Sept. 1, 1872	June 30, 1873	25,233 00	
Sidney F. Shelbourne, 11 Gold street, New York City.	30	14.98	At once.	June 30, 1873	17,679 20	
Wm. M. Tebo, Brooklyn, Long Island, New York.	30	30	Aug. 10, 1872	Aug. 1, 1873	33,300 00	
G. H. Ferris, Brooklyn, Long Island, New York.	30	16	Aug. 20, 1872	June 15, 1873	18,740 00	Conditional upon award of both bids.
Emory R. Seward, Albany, New York..	40	50	Sept. 1, 1872	June 30, 1873	54,800 00	
Morris & Cummings, New York City...	50	24.50	Sept. 1, 1872	June 30, 1873	28,980 00	Conditional upon award of both bids.
R. G. Packard & Co., 361 Fulton street, Brooklyn, New York.	67*	19†	Sept. 20, 1872	June 30, 1873	24,450 00	

* Sand, gravel, and bowlders. † Soft mud.

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The estimate for this work was $22,780.

It is thought that the present appropriation will complete the improvement. No appropriation is asked for the fiscal year ending June 30, 1874.

Huntington is in the New York collection-district; the nearest port of entry not learned.

The following are reports of the survey:

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, December 11, 1871.

GENERAL: I have the honor to present herewith the map and report of the survey of Huntington Harbor, Long Island, New York, made in accordance with your instructions, as authorized by section 3 of the act of Congress making appropriations for the improvement of rivers and harbors, &c., approved March 3, 1871. Along with these is sent also a copy of the map, scale $\frac{1}{10000}$, of the hydrographic survey of this harbor, made in 1836 by the party under the command of Lieutenant G. S. Blake, United States Navy; and also the published United States Coast Survey chart, scale $\frac{1}{30000}$, of Huntington Bay, which latter chart shows the surroundings of Huntington Harbor. The survey made this last summer under my direction was conducted by Mr. W. S. Edwards, civil engineer, and his report is annexed to mine. The map of this last survey is made in a scale of $\frac{1}{2500}$, and the soundings are reduced to depths below the mean low-water plane. It is important to bear in mind, in comparing this map with the United States Coast Survey maps, that the soundings on the latter are reduced to mean low water of spring tides, which level is .7 of a foot below the mean low water. The mean rise and fall of tide here is 7.6 feet; the mean rise and fall of spring tides is 9.2 feet; the mean rise and fall of neap-tides is 6.2 feet. Vessels can find 7 feet of depth at mean low water at the entrance to the harbor as it now is, in a channel about 80 feet wide at narrowest point, and they can carry this draught up to within 2,000 feet of the wharves at the head of the harbor. But at this point the harbor shoals suddenly so as to be nearly bare at low water, and the only draught that can be carried higher is that obtained by the rise of the tide. There has been little practical change in the condition of the harbor since the survey in 1836, and the only improvement to note consists in the removal of a large bowlder from the entrance. Mr. Edwards recommends the dredging of the entrance so as to make 8 feet at mean low water, with a channel 180 to 200 feet wide in the narrowest part. The material to be removed is sand, gravel, pebbles, and some bowlders, and, unless deposited in the flats at high water, it will have to be towed about three miles to deep water. This, he estimates, will require the removal of 6,600 cubic yards, costing, at 30 cents per cubic yard, $1,980. He also recommends the extension of the channel to the public wharf on the east side of the harbor, near its head, by dredging, so as to give a depth of 8 feet at mean low water, and a width at bottom of 150 feet. This material is soft mud. It can be deposited on the flats only at high water. At all other times it must be towed out into deep water, a distance perhaps of five miles. The estimated amount of material to be removed is 104,000 cubic yards, and the cost, 20 cents per yard, requiring $20,800.

The formation of the sand-spit on the east side of the entrance to Huntington Harbor shows that this entrance, like most others on the sound, is affected by the motion of sand westward along the shore; but the presence of bowlders in the shoal at the entrance renders it probable that this shoal is maintained at present depth in consequence of them, and that when these are dredged out the strength of the current may be able to keep the entrance sufficiently free thereafter of sand. I therefore recommend the trial of dredging at this point, and if it should turn out afterward that the shoal re-forms, we shall have to resort to jettees to keep the sand outside the entrance from drifting along the shore. The desired channel at the head of the harbor can only be obtained by dredging, and the character of the existing material there gives every assurance that a channel once opened will be kept open by the ordinary use; and I recommend this method of improvement there also.

The widening and deepening of the channel at the entrance will be of general benefit to the commerce of Long Island Sound, by increasing the facility of reaching it as a place of shelter in storms, for which purpose, on account of its being land-locked, it is much sought now by vessels whose draught will allow to avail of it. The business in the harbor would be much increased by making the new channel up to the wharves. The place is in the New York collection-district, from which it is distant by water thirty-five miles. The nearest port of entry is Cold Spring Harbor, which is but a few miles from it.

I append, as part of my report, the following statistics, furnished by Mr. Charles R. Street, of Huntington, who is secretary of the committee appointed by the residents to look after the interests of the place in connection with this survey.

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Commercial statistics of Huntington, Long Island.

Population of Huntington proper	3,000
Number of stores for the sale of merchandise	30
Markets, (number)	3
Manufacturing establishments, earthenware, sash and blinds, and carriages	11
Churches	5
Public halls	3
Schools, one union, with attendance of about	300
Valuation of property, real and personal, based on assessors' books	$2,500,000
Number of packet-vessels engaged in trade with New York City regularly, average about 100 tons	4
Number of vessels freighting regularly between here and other ports	15
Estimate of transient vessels freighting between here and other ports	25
Tons of merchandise landed at this port each year	5,000
Tons of other freight landed here each year	25,000
Tons of freight sent out of here each year	30,000
Number of sails appearing in these waters as a harbor of refuge during storms for one year, estimated at	5,000

Long Island Railroad has depot two miles off.

If it is decided to improve this harbor to the extent estimated for, it would be most economical to make the entire appropriation at once, the total of which would be $22,780.

Respectfully submitted.

G. K. WARREN,
Major Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers United States Army, Washington, D. C.

HUNTINGTON HARBOR,
Long Island, New York, September 28, 1871.

SIR: I herewith submit map of hydrographic survey of Huntington Harbor, Long Island, which has been made in accordance with your instructions of July 18, 1871, and the following report relative to it and the improvements desired:

The residents and others engaged in maritime trade at this port have thought that there are important changes in the entrance, or "gut," and also that the channels at the head of the harbor had shoaled by filling. On these grounds they asked for a new survey, for the purpose of showing these changes and devising some method to improve the depth of water at certain points in this harbor, so as to allow steamboats and vessels drawing 7 feet of water to pass up to the wharves at any stage of tide.

The survey was commenced August 1 and closed August 20, 1871. The weather being remarkably fine, no delay was met with. To facilitate the work, I adopted the United States Coast Survey determination of the "Mean Rise and Fall of Tides" in Lloyd's Harbor, and reduced the soundings of each day by the tides observed on that day. The soundings were mostly made with a pole divided to feet and half feet, the lines of soundings being run on ranges accurately determined. I measured a base (on the sand-spit east side of entrance) of 2,000 feet, and from that base carried a system of triangles to the head of the harbor, closing on a base of verification measured across the causeway 846 feet. The shore-line outside, and at the entrance to the harbor, was resurveyed. I have constructed the map of the area surveyed on a scale of $\frac{1}{2500}$, and the soundings give the depth at mean low water. The United States Coast Survey give depths at mean low water of spring tides.

In comparing this with that made by Captain Blake, United States Navy, assistant United States Coast Survey, in the year 1836, I can detect but few changes, and those are of minor importance. The channel-way through the "gut" remains almost identically the same, except that what was formerly a "middle ground," with a depth of 3 feet at mean low water of spring tides, seems to have joined the shoal putting out from the east side of the entrance and formed a tongue of shoal, but the depth of this has neither increased nor decreased. A dangerous rock, immediately in the channel, (shown on the Coast Survey printed map,) a little on the west side of the entrance, has been removed.

I recommend that this shoal be dredged, as marked in blue on the accompanying map, 685 feet in length, 130 feet in width, to an average depth of 8 feet. This will require the removal of 6,600 cubic yards of material, at an expense not exceeding 30 cents per yard. The material excavated can be deposited on the flats in Lloyd's Harbor, or to the eastward of the rocky point on east side of entrance. From the "gut"

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to a point about half way between Post's wharf and Johnson's wharf there is a good and plain channel, 8 feet deep at mean low water, as may be seen by reference to the map. From this point up to the old wharf, on the east side of the harbor, there is at low tide a mere drain about 1 foot deep at mean low water, which follows the curve of the shore. This shoal part the citizens desired to have deepened, so that steamboats and sailing-vessels drawing 7 feet water can pass up and down at all stages of tide. From the point where the natural channel heads up, I have dotted on my map in blue the project for the artificial channel proposed.

The first proposition is to carry a channel direct to the "old wharf," which is the property of the town. This would be the shorter and most direct channel. By it the distance to be excavated will be 2,000 feet in length, and, if dredged to the depth of 8 feet and to a width of 150 feet, will require the removal of 78,000 cubic yards of material.

The second proposition is to open the channel to the west side of the head of the harbor, as shown on the map by blue dotted lines. This distance is 2,250 feet, and to make the same depth and width will require the removal of 87,500 cubic yards. The material to be removed in both instances is a very soft mud or ooze that is from 6 to 8 feet in depth, as one goes from the bank to the center of the basin. Soundings were taken with a pole at several points to determine the depth of this soft mud. The results are marked on the chart in blue. At these points the pole was forced down through this soft mud until the resistance of clay or marl was met with.

The committee of citizens having the matter in charge, being composed of those more or less interested in one side or the other of the harbor, do not wish to press the merits of either side for the termination of the channel, but leave it entirely to the judgment of those expert in such matters to say which side should be selected.

On the score of economy the east side presents the strongest claim, also for its having been the original head of navigation and there being a public wharf at that point. On the west side, the proposed terminus of the channel is now the point of departure of the New York sailing-packets, and is also the outlet of a tide-mill whose dam is formed by the causeway at the head of the harbor, and the constant current from the mill-tail would be of assistance in keeping open a channel dredged here. The merits of the two points are about equally balanced. Huntington is only thirty-five miles by water from New York, and has a railroad connection with that city, the depot being about two miles from the center of the village. There can be no doubt that the opening of a channel up to the wharves would be of the greastest assistance in developing the growth of this place. It is remarkably healthy and well situated, and the harbor being completely land-locked, it is used a great deal as a harbor of refuge by vessels navigating Long Island Sound.

In making an estimate of the quantity of material to be removed in dredging out a channel, I make an allowance of one-third additional for the soft mud that will fill in as fast as removed, until the edges of the cut assume the proper angle. The material that is dredged out can be deposited on the flats at various points on the harbor without any injury to the channel.

RECAPITULATION OF ESTIMATES.

To remove shoal at entrance to harbor, 6,600 cubic yards, at 30 cents per yard	$1,980 00
To dredge channel to old wharf, 78,000 cubic yards, at 20 cents per yard	15,600 00
26,000 cubic yards, (one-third additional)	5,200 00
Total	22,780 00

I append to this report the observations on high and low water, made while carrying on the survey. Besides the map I have made, I send herewith a tracing from the original Coast Survey map, (scale $\frac{1}{10000}$,) executed in 1836, by the party in charge of Captain Blake, United States Navy, assistant United States Coast Survey; also the printed map, (scale $\frac{1}{30000}$.) In the field-work of this survey I have been ably assisted by Mr. C. E. Plumb, a civil engineer; also, in the hydrography, by Mr. James H. Porter, late United States Navy.

I remain, respectfully, yours, &c.,

W. S. EDWARDS,
Civil Engineer.

General G. K. WARREN,
Major Engineers, United States Army.

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T 14.

IMPROVEMENT OF PORT JEFFERSON HARBOR, NEW YORK.

In my annual report, dated August 31, printed with your annual report, pp. 804 and 805, I stated that contracts had been made for the work, under the appropriation of $15,000 approved March 3, 1871, and that a thorough survey, to enable me to make a proper location of the works, had been made.

The contractor for furnishing stone for the breakwater was also contractor for similar work at Block Island, Rhode Island, and Bridgeport, Connecticut.

Owing to the unfavorable weather last autumn, he was unable to finish the two latter only within the time named in his contracts. The time for completing this work was extended to the 15th of August, 1872. He commenced to deliver stone in the latter part of May, 1872, and at the expiration of his contract had placed 3,075 tons of granite in the breakwater.

The map of the entrance made by my direction, by Captain Edwards last summer, with his report dated January 17, 1872. These reports were printed as part of H. Ex. Doc. No. 136, Forty-second Congress, second session. The map fully confirms my views expressed in my report of January 16, 1871, pp. 805 to 811, of your last annual report.

Since Blake's survey in 1838, the entrance has moved westward 790 feet, or at the average rate of about 24 feet annually.

If this rate has been constant, it was only about one century ago when the entrance was at the foot of Mount Misery Point, on the west side. If not arrested, the movement westward will continue until some barrier near the west side of the harbor is reached, when the sea will probably break through again near Mount Misery Point, where it already shows a tendency to do, and then this movement will repeat itself, as it probably has many times before in past ages.

Should a channel form near Mount Misery it would furnish a better location than any other for the entrance, on account of the fine land-mark this headland presents the mariner, but I do not think it advisable to attempt to form an entrance there artificially. I have marked on the map the position proposed for the breakwater, and as this is extended the motion of the pebbles and stones from Mount Misery westward will be stopped, and they will cease to fall into the channel. It may then be necessary to dredge in the channel, to aid the current in removing those now there, but it is believed that after that the scour of the tide will clean out anything that may be around the breakwater. The velocity is sometimes 10 feet a second.

I append the report of Captain Edwards, civil engineer, on the survey of this harbor.

Under the appropriation of $15,000 made by act of Congress approved June 10, 1872, advertisements were issued June 28, 1872, asking for proposals for doing the work according to the following specifications:

For continuing the breakwater there are required 5,000 tons of riprap granite blocks averaging not less than 1½ tons each, and none weighing less than one-half of a ton. They should be as nearly cubical as practicable, the smallest dimension not being less than one-third of the greatest.

The breakwater is to be triangular in cross-section, with side slopes of 45°, and to be built to the level of high water. It is now completed out to a depth of 1 foot at mean low water. The tide rises about 7 feet.

The stone can be deposited in the work from the deck of vessels with a common spar-derrick. The tide falls so rapidly, however, that a vessel drawing as much water as there is tide cannot unload fast enough to keep afloat, and the work would be better and more quickly done if the contractor should keep a lighter, provided with derrick, solely for use at this place. The situation is exposed to the waves of the sea in northerly winds.

Proposals will state the price per ton placed in breakwater.

The following is an abstract of proposals received:

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Abstract of proposals for the improvement of Port Jefferson Harbor, Long Island, New York, received at the engineer office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Price per ton for granite.	Commence—	Complete—	The amount of stone required, (5,000 tons,) at price named, would cost—	Remarks.
John Beattie, Stony Creek, Connecticut.	$2 67	Aug. 10, 1872	May 10, 1873	$13,350 00	Bids for 5,000 tons. No witness to signatures of guarantors.
Thomas G. Cochran, Astoria, Long Island, New York.	2 84	Sept. 10, 1872	June 30, 1873	14,200 00	Bids for 5,000 tons. No witness to signatures of guarantors, and no certificate that guarantors are responsible parties.
Francis H. Smith, 121 Front street, New York City.	3 19	Aug. 15, 1872	June 30, 1873	15,950 00	
Andrew W. McKee, Huntington, Long Island, New York.	3 25	Aug. 20, 1872	June 30, 1873	16,250 00	Proposal for this work, New Haven Harbor, Connecticut, and Bridgeport, Connecticut, all on the same blank.
D. V. Howell, 141 Chambers street, New York City.	3 27	Sept. 1, 1872	June 30, 1873	16,350 00	
C. W. Campbell & Co., Lyme, Connecticut.	3 47	Aug. 15, 1872	June 30, 1873	17,350 00	

The contract was awarded to John Beattie, of Stony Creek, Connecticut, the lowest bidder, at $2.67 per ton. Mr. Beattie commenced to deliver stone in August, and up to the 31st of the month had put in 610 tons in position in the breakwater.

There is every reason to believe that when the breakwater is completed out to deep water, so that no material can pass around the end, and the channel dredged, the tidal flow will keep this entrance open at any depth made.

Port Jefferson is a port of entry. It is in the New York collection-district.

The amount asked to continue this improvement during the fiscal year ending June 30, 1874, is $20,000.

Statement of funds.

Amount available July 1, 1871	$15,000 00
Amount appropriated by act of June 10, 1872	15,000 00
Amount expended during fiscal year ending June 30, 1872	4,231 72
Amount available July 1, 1872	25,760 28
Amount required for fiscal year ending June 30, 1874	20,000 00

PORT JEFFERSON,
Long Island, New York, January 1, 1872.

GENERAL: In accordance with your instructions of May 12, 1871, I have made the hydrographic and topographic survey of the entrance to Port Jefferson, Long Island, including the sand-spits on either side of the entrance, and herewith submit the following report of these operations, together with the finished chart of the entrance, on the scale of $\frac{1}{2500}$, which shows the contour lines on the sand-spit on east, or Mount Misery, side; also record of tidal observations made during one lunar month.

The working party was organized May 29, and the survey was prosecuted to the close, on July 11, without any serious delay. Owing to the very strong current setting in and out of the harbor, accurate soundings could only be taken during a short time before and after the high and low waters of each day.

There were two tide-gauges established and secured by bench-marks, one outside

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and the other inside the harbor. This I found necessary on account of the constant difference in the level of the water inside and outside.

At the inside gauge a full and perfect set of tides was observed, from which the mean high and low water and other constants connected with the tides were determined. At the outside gauge, observations were made during the time of sounding outside, and also the rise and fall, for the purpose of comparison with the inside gauge.

The gauge outside being exposed to considerable sea during northerly winds, it was necessary to use something different from the ordinary harbor-gauge, and, after several trials, we succeeded in making our stand, which consisted of a tripod of 4-inch round iron, legs well spread, and light iron braces from leg to leg, about two feet from bottom of leg; on these braces laid cross-boards, and weighted down with heavy stone; the upper ends of legs of tripod secured to an iron collar; the graduated rod passed down through this collar, and through a hole in the boards, at the bottom resting on the sand. It is read from the beach with a glass. This has stood very well up to the present time.

A base line of 2,400 feet was measured on the Mount Misery sand-beach, signals erected, the necessary points determined, and the whole connected with the geodetic points of the Coast Survey, for the purpose of comparison.

In making a comparison of the tides inside with those outside, I have noted the following peculiarities:

*First. The actual amount of rise and fall at both gauges was the same, unless influenced by the winds.

Second. The duration of rise and fall was the same.

Third. The duration of slackwater was the same.

Fourth. The time of high water inside was thirty minutes later than outside.

Fifth. The time of low water inside was one hour and ten minutes later than outside.

The greater difference was at one-half flood, when the water outside stood 2.1 feet higher than the water inside.

I append herewith abstract of full set tides observed:

Mean rise and fall	5.92 feet
Mean duration of rise from middle of one stand to middle of the next	5h 37m
Mean duration of fall from middle of one stand to middle of the next	6h 48m
Mean duratjon of stand	0h 24m
Rise of highest tide above plane	5.50 feet
Fall of lowest tide below plane	0.60 feet

The principal changes shown by a comparison of the survey of 1838 with the present one are, first, the extension of the sand-spit on the east, or Mount Misery, side of the entrance 790 feet, and the change of the channel from the east to the west side of a small sand island just inside the entrance. The depth remains the same as it was in 1838, viz, two feet on the bar at low water. There is a peculiarity on this bar that I have never noticed anywhere else along the sound; that is, the formation of a muscle-bed just outside the narrowest part of the entrance.

The muscles are in layers, and the latter nearly a foot deep. They are taken up in large quantities by oyster-tongs, and sold to the farmers, to be used as a fertilizer.

In making this survey I have been assisted by Mr. Charles E. Plumb, a civil engineer, and also by Mr. Porter, lately of the Navy.

Very respectfully, your obedient servant,

W. S. EDWARDS,
Civil Engineer.

General G. K. WARREN,
Major United States Engineers.

*NOTE.—This is incorrect. See note at the end of the tide-tables in this report.

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Abstract of Port Jefferson, Long Island, tides.

Date.	INSIDE GAUGE.					OUTSIDE GAUGE.			
	Time of—		Rise.	Fall.	Stand.	Time of—		Rise.	Fall.
	High water.	Low water.				High water.	Low water.		
1871.			*Feet.*	*Feet.*	*Min.*			*Feet.*	*Feet.*
June 2		5. 20 p. m			20				
June 2	11. 00 p. m		7. 40		20				
June 3		6. 20 a. m		7. 50	20				
June 3	11. 20 a. m		6. 30		20				
June 3		6. 20 p. m		6. 10	10				
June 3	11. 50 p. m		7. 40		10				
June 4		7. 00 a. m.		7. 50	50				
June 4	12. 20 p. m		6. 40		30				
June 4		6. 50 p. m		6. 00	30				
June 5	12. 40 a. m		7. 40		10				
June 5		8. 10 a. m		7. 70	30				
June 5	1. 20 p. m		6. 50		20				
June 5		7. 50 p. m		6. 10	30				
June 6	2. 20 a. m		7. 30		20				
June 6		9. 10 a. m		6. 70	20				
June 6	2. 10 p. m		6. 30		20				
June 6		9. 00 p. m		6. 10	10				
June 7	2. 50 a. m		6. 80		20				
June 7		9. 40 a. m		6. 90	20				
June 7	3. 00 p. m		6. 30		20				
June 7		9. 50 p. m		6. 60	30				
June 8	3. 40 a. m		6. 80		30				
June 8		10. 40 a. m		6. 50	30				
June 8	4. 10 p. m		5. 80		20				
June 8		10. 40 p. m		5. 50	20				
June 9	4. 30 a. m		5. 50		30				
June 9		11. 30 a. m		5. 80	30				
June 9	5. 10 p. m		5. 90		30				
June 9		11. 50 p. m		5. 70	30				
June 10	5. 30 a. m		5. 30		30				
June 10		12. 50 p. m		5. 50	20				
June 10	6. 10 p. m		5. 80		10				
June 11		12. 50 a. m		5. 50	30				
June 11	6. 40 a. m		5. 30		10				
June 11		1. 30 p. m		5. 40	30				
June 11	7. 00 p. m		5. 70		30				
June 12		1. 50 a. m		5. 60	10				
June 12	7. 40 a. m		5. 30		20				
June 12		2. 00 p. m		5. 00	10				
June 12	7. 40 p. m		5. 50		20				
June 13		3. 00 a. m		5. 90	40				
June 13	8. 20 a. m		5. 00		10				
June 13		2. 50 p. m		4. 90	30				
June 13	8. 40 p. m		5. 60		20				
June 14		3. 50 a. m		6. 00	20				
June 14	9. 20 a. m		5. 10		30	8. 50 a. m			
June 14		3. 20 p. m		4. 60	10		2. 30 p. m		5. 00
June 14	9. 30 p. m		5. 60		30				
June 15		4. 30 a. m		6. 10	20				
June 15	10. 00 a. m		5. 30		30	9. 40 a. m			
June 15		4. 10 p. m		4. 80	20		3. 20 p. m		5. 20
June 15	10. 20 p. m		5. 70		40				
June 16		5. 00 a. m		6. 10	30	10. 00 a. m		5. 30	
June 16	10. 30 a. m		5. 30		20		3. 50 p. m		5. 10
June 16		5. 10 p. m		5. 10	30				
June 16	10. 40 p. m		5. 90		10				
June 17		6. 00 a. m		6. 30	20		4. 50 a. m		
June 17	11. 20 a. m		5. 50		40	10. 40 a. m		5. 50	
June 17		5. 30 p. m		5. 10	20		4. 40 p. m		5. 10
June 17	11. 30 p. m		5. 70		20				
June 18		6. 30 a. m		6. 10	30				
June 18	11. 40 a. m		6. 00		20				
June 18		6. 00 a. m		4. 90	20				
June 18	11. 50		6. 00		20				
June 19		7. 10 a. m		6. 60	20		5. 40 a. m		
June 19	12. 30 p. m		5. 20		20			5. 20	
June 19		6. 50 p. m		5. 10	40		6. 00 p. m		5. 10
June 20	12. 30 a. m		5. 80		30				
June 20		7. 30 a. m		6. 10	40		6. 40 a. m		
June 20	1. 00 p. m		5. 50		30	12. 30 p. m		5. 50	
June 20		7. 20 p. m		5. 10	30		6. 40 p. m		5. 10
June 21	1. 10 a. m		5. 40		40				
June 21		8. 10 a. m		6. 00	30		7. 10 a. m		
June 21	1. 50 p. m		5. 50		20	1. 30 p. m		5. 50	

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Abstract of Port Jefferson, Long Island, tides—Continued.

Date.	INSIDE GAUGE.					OUTSIDE GAUGE.			
	Time of—		Rise.	Fall.	Stand.	Time of—		Rise.	Fall.
	High water.	Low water.				High water.	Low water.		
1871.			*Feet.*	*Feet.*	*Min.*			*Feet.*	*Feet.*
June 21		8. 20 p. m		5. 10	30				
June 22	2. 10 a. m		5. 50		00				
June 22		9. 20 a. m		6. 00	30		8. 00 a. m		
June 22	2. 20 p. m		5. 50		20	2. 10 p. m		5. 50	
June 22		9. 00 p. m		5. 00	30				
June 23	2. 50 a. m			5. 40	20				
June 23		9. 40 a. m		5. 90	30		8. 30 a. m		
June 23	3. 20 p. m		5. 50		20	2. 50 p. m		5. 50	
June 23		9. 40 p. m		5. 00	40				
June 24	3. 40 a. m		5. 30		30				
June 24		10. 10 a. m		5. 40	30		9. 30 a. m		
June 24	4. 20 p. m		6. 10		20	3. 30 p. m		6. 50	
June 24		11. 50 p. m		5. 80	30				
June 25	4. 20 a. m		5. 30		20				
June 25		11. 00 a. m		5. 50	40		10. 30 a. m		
June 25	5. 00 p. m		5. 50		10	4. 20 p. m		6. 10	
June 25		11. 50 p. m		5. 70	20				
June 26	5. 20 a. m			5. 10	20	4. 40 a. m			
June 26		12. 00 m		5. 40	40		10. 50 a. m		5. 40
June 26	6. 00 p. m		6. 00		20	5. 30 p. m		6. 50	
June 27		12. 40 a. m		5. 80	30				
June 27	6. 10 a. m		5. 10		40	5. 50 a. m			
June 27		12. 50 p. m		5. 10	40		12. 10 p. m		5. 70
June 27	6. 40 p. m		6. 20		30	6. 20 p. m		6. 90	
June 28		2. 00 a. m		6. 20	20				
June 28	7. 30 a. m		5. 80		20	6. 50 a. m			
June 28		1. 50 p. m		5. 60	40		1. 00 p. m		6. 10
June 28	7. 50 p. m		6. 60		20				
June 29		3. 00 a. m		6. 80	20				
June 29	8. 20 a. m			5. 80	30	7. 50 a. m			
June 29		3. 00 p. m		5. 90	30		2. 00 p. m		6. 60
June 29	8. 30 p. m		6. 80		40				
June 30		4. 00 a. m		7. 10	40				
June 30	9. 30 a. m		6. 10		10	9. 00 a. m			
June 30		4. 06 p. m		5. 90	20		3. 00 p. m		6. 70
June 30	9. 50 p. m		7. 00		10				
July 1		5. 20 a. m		7. 20	20				
July 1	10. 30 a. m		6. 10		10	10. 00 a. m			
July 1		5. 20 p. m		6 10	10		3. 50 p. m		7. 30
July 1	10. 50 p. m		7. 40		10				
July 2		6. 20 a. m		7. 50	10				

NOTE.—According to the tide-records in the above table, and from observations made in 1872, it appears that the high-water planes inside and outside the entrance are the same, but that the low-water plane outside is three inches lower than inside.

G. K. WARREN.

T 15.

IMPROVEMENT OF PECONIC RIVER, LONG ISLAND, NEW YORK.

With the amount appropriated by act approved March 3, 1871, $5,000, a channel, about 25 feet wide and 4 feet at mean low water, was opened up to Riverhead. The mean rise of the tide is about 2½ feet.

I send herewith a detailed report of the operation and estimates of remaining work to be done, made by Mr. H. S. Van Ingen, civil engineer, who superintended the work. This was printed as part of H. Ex. Doc. No. 136, Forty-second Congress, second session.

Mr. Van Ingen estimates that to make a channel 75 feet wide and 6 feet deep at mean low water, up to Merritt's Bay, will require an additional sum of $28,000.

Under the appropriation of $10,000 made by act approved June 10,

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1872, advertisements were issued June 28, 1872, for proposals for doing the work according to the following specifications:

Dredging is to commence near Indian Island and be continued up as far as the available funds will pay for it.

The principal part of the work will be between Indian and Colonel's Islands. The material dredged in this portion can be dumped in a distance of from 1 to 3 miles with scows of 5 feet draught, at any time of tide; at high water dumping with scows of this draught can be done on adjacent flats.

The mean rise and fall of tide is about 2.6 feet.

Proposals will state price per cubic yard, measured in scows, for dredging.

Mr. Morris F. Brainard, of Albany, New York, having done the work during the last year, and his proposal being the lowest with the exception of one, which was at the same price, was awarded the contract.

The following is an abstract of the proposals received:

Abstract of proposals for the improvement of the Peconic River, Long Island, received at the engineer office, United States Army, Newport, Rhode Island, Tuesday, July 30, 1872.

Name and address of bidder.	Price of material dredged.	Commence—	Complete—	Amount appropriated, at the price named, would remove—
	Cub. yd.			*Cubic yards.*
Morris F. Brainard, Albany, New York	$0 24	Aug. 15, 1872	Dec. 30, 1872	41,666
William M. Tebo, 77 Woodhull street, Brooklyn, New York.	24	Aug. 10, 1872	Dec. 1, 1872	41,666
H. N. and A. J. Beardsley, Bridgeport, Connecticut	33	Aug. 10, 1872	Jan. 1, 1876	30,303

The improvement of this river, inaugurated last season by the General Government, has been seconded by the State of New York with an appropriation of $15,000. It is important that the work be carried on until the 6-foot channel is extended up to Riverhead. I recommend that an appropriation of $10,000 be made to carry on this work during the fiscal year ending June 30, 1874.

Peconic River is in the Sag Harbor collection-district. Sag Harbor is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1872, was $963.12.

Statement of funds.

Amount available July 1, 1871	$5,000
Amount appropriated by act of June 10, 1872	10,000
Amount expended during the fiscal year ending June 30, 1872	5,000
Amount available July 1, 1872	10,000
Amount required during the fiscal year ending June 30, 1874	10,000

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, December 18, 1871.

GENERAL: I have the honor to make the following final report of operations for the improvement of Peconic River, Long Island, New York, conducted in accordance with section 1 of the appropriation act for rivers and harbors, approved March 3, 1871. The amount of the appropriation was $5,000.

Peconic River, or that portion of it possessing the possibilities of navigation, is three miles long, emptying into Peconic Bay. At its head is Riverhead, the county-seat of Suffolk County, a thriving little place of about 1,800 inhabitants. Several mills are in operation here, run by steam and water power. The river is principally used for transporting coal and lumber, and some merchandise, to Riverhead, and for the shipping of

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wood; the former articles are sent to the south side of the island and into the interior in large quantities, and on this fact are based the petitions for appropriations by Congress for the improvement of Peconic River.

Ordinary sized vessels, with cargoes for Riverhead, can carry 6 feet of water to the mouth of the river at Indian Island. Here they transfer their loads to scows, being unable to proceed farther. Smaller vessels and scows can reach Colonel's Island, a mile and a half up, through a narrow winding channel, at all stages of the water. Above this they could proceed only at not less than average high water. There were, therefore, two methods of improving the river with the funds appropriated:

First. To begin at the mouth, and enable large vessels to approach a little nearer to the town, the material dredged to be removed in scows.

Second. To render it possible for smaller vessels and scows to reach Riverhead at all times, and thus prevent much delay, the material to be dumped over the side of the dredge, on land, when possible.

The amount of the appropriation was so small as to have rendered the advantages to be obtained from carrying out the former plan very trifling. It was, therefore, deemed advisable to expend the money, with one exception, in accordance with the second method, and thus directly and thoroughly assist the inhabitants of Riverhead. Had the only advantage derived been the demonstration to the people of Riverhead of the feasibility of the improvement of Peconic River at small expense, the appropriation would have been well expended.

The dredging was begun August 5, and completed October 3, with an Osgood dredge furnished by Morris F. Brainard, at $8.75 per hour. It was performed at three different points, shown on the map accompanying this report.

First. At the "Crook," in the channel near the mouth.—It was deemed advisable to take off the sharp point at this place by making one cut across it, the material being dumped over the side of the dredge, to be removed when the work shall be thoroughly performed; a depth of at least five feet of water was secured at low water.

Second. Above Colonel's Island.—Here a channel 25 feet wide, 700 feet long, was dredged to connect the deeper water above and below this shoal. In this stretch and the succeeding one a depth of four feet was desired; this was exceeded most of the distance however, as a depth greater than this could be made without extra expense, the dredge being paid by the hour.

Third. From Merritt's Bay up to Riverhead.—A channel 3,006 feet long, 25 feet wide, and 4 feet deep, at least, was made, extending within about 350 feet of the head of the navigable portion of the river. The material was thrown on the shore a good part of the way; where the bank raised was above high-water mark, it was leveled back from the channel.

The cuts made are indicated on the map, together with the banks thrown up, the material being indicated by the conventional colors. On the completion of the work conducted at Government expense, the citizens of Riverhead continued the channel to the head of navigation; this is indicated on the map by red.

Should another appropriation be made by Congress for the improvement of Peconic River, I would suggest that it be expended in making a 75-foot wide and 6-foot deep channel, this to begin at Indian Island. It should be extended at least to Colonel's Island, and to Howell's Dock, or Merritt's Bay, if possible.

The following is an estimate of the number of cubic yards of material necessary to be removed to obtain such a channel, and the cost of removal:

To Colonel's Island:	
28,423 cubic yards mud, at 25 cents per yard	$7,105 75
From Colonel's Island to Howell's Dock:	
28,849 cubic yards sand, mainly at 30 cents per yard	8,654 70
From Howell's Dock to Merritt's Bay, west end:	
31,457 cubic yards sand, mainly at 30 cents per yard	9,437 10
Total to Merritt's Bay	25,197 55
Engineering expenses 10 per cent. added	2,519 75
	27,717 30

All the material excavated should be carried off in scows; these, if small, could at high water be dumped on the flats, or they could be towed about a mile below Indian Island at any stage of the tide.

There accompanies this report a copy of the tidal observations taken for one lunar month, together with the reference of mean low water to a bench-mark therein described.

Very respectfully,

HENRY S. VAN INGEN.

Brevet Major-General G. K. WARREN,
Corps of Engineers, U. S. A., Newport, R. I.

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Record of tidal observations kept in Peconic River, Long Island, just west of Merritt's Bay, from August 21 to September 17.

Date.	High water.	Low water.	Rise.	Wind.	Remarks.
	Feet.	*Feet.*	*Feet.*		
Aug. 21	3.5	.8	2.7	E. S. E.	N. B.—The record was not kept on Sundays.
22	3.2	.9	2.3	E.	
23	3.4	.7	2.7	S. W.	
24	2.4	.5	1.9	S. W.	
25	2.3	.4	1.9	S. W.	
26	2.7	.6	2.1	S. W.	
28	2.6	.5	2.1	S. E.	
29	3.1	.3	2.8	S. W.	
30	3.4	.4	3.0	S. W.	
31	2.8	.3	2.5	N. W.	
Sept. 1	3.4	.3	3.1	E.	
	3.4	.5	2.9	E.	
	3.1	.4	2.7	E.	
	3.0	.5	2.5	E.	
	2.7	.5	2.2	S. W.	
	3.0	.9	2.1	N. E.	
	2.8	1.1	1.7	N. E.	
	2.4	.7	1.7	W.	
	2.8	.9	1.9	N. W.	
	2.6	.4	2.2	N.	
	2.6	.1	2.5	S. W.	
	3.0	.1	2.9	N. E.	
	3.7	.4	3.3	S. E.	
	3.4	.8	2.6	N.	

	Feet.
Mean high water	2.97
Mean low water	.54
Mean rise and fall	2.43

Mean low water, as thus determined, is 7.843 feet below the top of the facing-stone of the south side of the cellar-stairs of the store of Messrs. Skidmore & Vail. The rod was held on the inner edge, over the center drill-hole used in splitting the stone.

The highest tide of which any record could be found occurred in the spring of 1867. It was 6.8 feet above mean low water, as determined above.

HENRY S. VAN INGEN.

T 16.

SURVEY OF STONINGTON HARBOR, CONNECTICUT.

This survey was completed last season, and a map and report were submitted dated December 18, 1871, and printed as part of Senate Ex. Doc. No. 23, second session Forty-second Congress. No appropriation was made by Congress for this work. I append my report upon this survey:

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, December 18, 1871.

GENERAL: I have the honor to present herewith the map and report of the survey of the harbor of Stonington, Connecticut, made in accordance with your instructions, as authorized by section 3 of the act of Congress making appropriations for the improvement of rivers and harbors, &c., approved March 3, 1871. Along with these is also a copy of the United States Coast-Survey published chart of Fisher's Island Sound on a scale of . . . from the hydrographic survey made in 1839, which shows the frontage on the ocean. I would also refer you to the copy of the United States Coast-Survey chart of Pawcatuck River on a scale of $\frac{1}{10000}$, which I sent you with my map of the Pawcatuck River and report dated January 17, 1871. This chart exhibits the hydrographic survey in the harbor, made in 1839, in more detail than the other. It is a little inaccurate in the contours at Wampasset Point southwest of Stonington. I would also refer you to the original map, (scale 1 foot to a mile,) made in 1837 by Lieutenant J. Prescott,

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First Regiment Artillery, on file at your headquarters, for the representation of the harbor as it was before the breakwater was built.

The breakwater was built under appropriations made in 1828, 1830, and 1834, at a cost of $36,753.83. It would cost much more to build it now. It is in very good condition at this time. For details of its structure, I refer to the accompanying report of Mr. Dager, civil engineer, who made the survey this year.

The space inclosed from the action of the gales and waves during southeasters began to fill up on the completion of the work. Comparing Prescott's map of it in 1827 with that of the Coast Survey in 1839 we see that the 12-foot curve was about 200 feet farther out from shore in 1839 than in 1827, and putting these curves on the map of the survey of it, as it now is, shows that since 1839 the 12-foot curve has been moved out 150 feet farther, and is now within 70 feet of the end of the breakwater, which structure has thus ceased to be available to shelter vessels drawing over 12 feet. Formerly it was stated that fifteen to eighteen vessels of 15 foot draught could anchor behind it.

There is now a narrow channel of 12 feet water leading up to the steamboat wharf which does not appear on the Coast Survey chart, and it has probably been since produced by the dredges employed by the steamboat company.

Appended to Mr. Dager's report is a communication addressed to him by Mr. Gould Stanton, warden of Stonington, and indorsed by twenty-two other citizens, stating the kind of improvement desired and the importance of it, and I ask attention to it and other papers accompanying his report. In this it is said:

"We wish it distinctly understood that in asking for the improvement under consideration, it is not for the benefit of any local interest, but for the benefit of commerce generally; that it is needed for the better protection and accommodation of thousands of vessels freighted with many millions of dollars which pass this port annually."

I believe the locality is an important one, as a harbor of refuge for coasters, and it is also well situated to receive vessels arriving from the Atlantic Ocean, between Block Island and Montauk Point, as some do, with valuable cargoes from the South. The present harbor is undoubtedly an insufficient shelter for the demands of the case, which require as good harbor as can reasonably be made.

Mr. Dager in his report discusses several plans that have been suggested, and gives estimates of the cost of executing them, and the facilities they would afford. The one he recommends, however, is the only one I think worth considering. This plan proposes to remove the present structure to Stonington Point, so as to have it extend out about 900 feet in a direction south 55° west. The end of the breakwater would then be in 17½ feet water at mean low tide. He estimates that the change can be made for $181,000. I think this would not give sufficient shelter, and that it should be extended out 2,000 feet from the shore, where its extremity will be in 18½ feet water. I think, too, that it would be well not to disturb the present work until the new one is so far built as to make all the shelter now given.

I adopt the plan of Mr. Dager to build also a sea-wall from Wampasset Point, southeasterly out to the 12-foot curve. There will thus be an anchorage of 2,000 by 1,000 feet for vessels drawing from 15 to 18 feet water, and much more for those of smaller draught, which can be made to accommodate larger vessels by dredging. The space proposed to be inclosed by the breakwater is about all there is between the headlands formed by Stonington Point and Wampasset Point.

1. The breakwater from Stonington Point: The substructure to rise to level of mean low water, and to be there 20 feet wide, outside slope 1 upon 3, inside slope 1 upon 1, to be 2,000 feet long, requiring 66,666 cubic yards, which, allowing for interstices, would in granite blocks of irregular shapes, and not varying much from 1 to 3 tons each, require 1½ tons per yard, or 100,000 tons, at $2 per ton	$200,000
For wall of granite blocks, each 18 to 24 inches thick and regular shapes, bolted and clamped together with gun-metal, the wall to be 8 feet high, 8 feet wide on top, and 12 feet on bottom, and 2,000 feet long, 6,000 cubic yards, at $25	150,000
2. For sea-wall at Wampasset Point: To be of irregular blocks of about 1 ton weight; rising up to high-water line and sloping each side 45°, 20,000 tons, at $2	40,000
3. For engineering, superintendence, &c	30,000
	420,000

The whole work could be done in three years if ample appropriation was made at the start, so as to justify proper outlay for preparation for work.

Stonington is in the collection-district of Stonington, and it is a port of entry. The revenue collected there the fiscal year ending June 30, 1871, was $2,500; for the fiscal year ending June 30, 1872, $33,500; but this is no measure of the importance of the port

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ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, December 1, 1871.

GENERAL: I have the honor to submit the following report of a survey of Stonington Harbor, Connecticut, with plans for improving and extending the anchorage capacity of the said harbor. The survey was made in pursuance of instructions received from you, dated June 15, 1871.

From a preliminary examination of the case, it was apparent that the anchorage-ground in the harbor was entirely too limited, and from a conference with those in the vicinity interested in its improvement, the only object asked for was the extension of the harbor in such manner as to afford security to all vessels that might have to put in there from any cause whatever. The survey of the harbor was made with a view to securing this result. The map is drawn to a scale of $\frac{1}{2400}$. The soundings are reduced to the plane of mean low water, and are expressed in feet and tenths. Contour lines of planes of every 3 feet in depth are shown.

The mean rise and fall of the tide is 2.71 feet. Mean low water at Rodman's wharf is 21.43 feet, below the top of the lower step, at the west door of light-house.

During the survey, tide-gauges were established at Rodman's wharf, Stonington, at Lottery, on Pawcatuck River, and at Westerly, at head of navigation on Pawcatuck River.

Gauge-readings at Stonington were taken every fifteen minutes, day and night, for twenty-three days. At Lottery and Westerly simultaneous observations with the above were taken daily for seven days, sufficient to insure the recording of one high and one low water each day.

For the establishment of mean low water at Stonington, gauge-readings from June 21 to July 5, inclusive, were used, being one-half a lunation.

I append to this report tabulated records of the gauge-readings at Stonington, Lottery, and Westerly.

The positions of the bench-marks mentioned below are shown on the map.

Station E 26, (on breakwater,) is 7.97 feet above mean low water.

Station E 25, (on breakwater,) is 8.78 feet above mean low water.

Station E 24, (on breakwater,) is 8.68 feet above mean low water.

A survey of this harbor was made in 1827 by Lieutenant J. Prescott, First Artillery, United States Army, for the purpose of "ascertaining the expediency and expense of erecting a pier for the improvement of the same." The present breakwater was constructed in accordance with the first modification of Lieutenant Prescott's plan. (See his report to Lieutenant Colonel J. Anderson, December 1, 1827.)

The present anchorage-ground, protected by the breakwater of 12 feet in depth, is very small, having an area of 100,000 square feet that is secure from heavy south and southeast winds. When the breakwater was built, according to Lieutenant Prescott's report, there was room for fifteen or eighteen vessels, drawing 15 feet, to anchor and be protected by it; but this space has since much filled up.

The following methods of improving the harbor have been suggested:

1st. To dredge out the harbor above the steamboat wharf over the whole ground included between the 6-foot contours (see map) so as to give a depth of 15 feet at mean low water.

This plan would necessitate the removal of 536,460 cubic yards of material, principally sand, at 22 cents per yard, including superintendence, &c., would cost $118,019. In addition to this, a channel of sufficient width for vessels to beat in and out of this anchorage-ground would have to be dredged.

For this purpose a channel 500 feet wide would be necessary and require the removal of 96,300 cubic yards, which, at a cost of 22 cents per yard, including superintendence, would make $21,186, making a total of $139,205.

2d. To dredge out to the above-mentioned depth the space bounded north by the steamboat wharf; south, by the breakwater; east, by the docks, and west by a line drawn from the head of the breakwater to the head of the steamboat wharf.

This plan would require the removal of 233,575 cubic yards of material, costing, at 22 cents per yard, $51,368.50. This would be only a temporary improvement, the whole space having filled in very much since the construction of the breakwater, and always will fill, from the relative shapes and positions of the steamboat docks and the breakwater.

3d. To dredge out the whole of Penguin Shoal to a depth of 15 feet, at mean low water.

This plan would require the removal of 303,680 cubic yards of material, which, at 33 cents, including superintendence, &c., amounts to $100,214.40. A portion of this shoal is covered with small bowlders, therefore its removal is estimated at a higher price than that from the other localities. Vessels have lost their copper and damaged their bottoms scraping on the overlying bowlders.

This plan would give sufficient anchorage-ground for a large number of vessels, but in case of storms no protection whatever. The strongest ground-tackling would be unable to hold them while storms from the south or southeast were raging. A modifi-

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cation of this plan would seem to be better, but yet entirely insecure, namely, that of removing that part of Penguin Shoal within the bounds above stated, north of a line drawn from the end of the breakwater due west. This would leave the lower part of the shoal which would act as a barrier to deep seas and tend to break their force. This modified, the amount of material to be removed would be 187,560 cubic yards, costing, at 27½ cents, $51,579.

4th. To dredge a channel in depth as before mentioned, 500 feet wide, from below the end of the breakwater to the end of the steamboat wharf.

This plan would require the removal of 96,300 cubic yards, which, at 20 cents, would amount to $19,260. Add 10 per cent. for superintendence, &c., makes a total of $21,186. This plan would not much increase the anchorage-ground, and vessels would be scarcely better protected from heavy seas than they would be if the removal of Penguin Shoal was adopted. This channel would contain within its limits the channel now used by the line of steamboats running between Stonington and New York, and really would be an improvement of a channel for their use, as few vessels would anchor in it.

Those frequenting the harbor are very much afraid of these boats, a number of vessels having been run into and damaged by them.

During the prevalence of storms, darkness, fog, &c., no vessel would be secure lying in the path used by a night-line of steamers.

It is stated that on this account many of the coasters will not use the harbor at all, while many others prefer anchoring outside the breakwater rather than run any risk of anchoring near this channel-way.

The fifth plan suggested the removal of the breakwater to Rodman's wharf or Stonington Point. The latter is preferable on account of the shoal running off of the point, and also giving a much larger area.

After a due consideration of all methods suggested this latter seems to have the most weight.

The existing breakwater is built of durable stone, averaging about one and one-quarter tons each. It is 12 feet wide at top, having a slope of three to one on the outside and one-quarter to one on the inside.

The top is about 8½ feet above mean low water. The substructure is of angular blocks of stone thrown in, the superstructure consists of seven courses of split granite, placed. The top course is of headers; the others of headers and stretchers.

A number of the stones were measured, with the following results: 8 feet long, 2 feet wide, 1 foot thick; 6 feet long, 5 feet 6 inches wide, 1 foot 2 inches thick; 4 feet 6 inches long, 3 feet 2 inches wide, 1 foot 1 inch thick; 4 feet 6 inches long, 2 feet 8 inches wide, 1 foot 1 inch thick; 3 feet 7 inches long, 1 foot 10 inches wide, 1 foot 2 inches thick; 8 feet long, 2 feet wide, 1 foot thick; 5 feet 10 inches long, 5 feet 4 inches wide, 1 foot 3 inches thick; 4 feet 8 inches long, 2 feet 5 inches wide, 10 inches thick; 3 feet 10 inches long, 2 feet 7 inches wide, 11 inches thick.

Round granite snubbing-posts, about 3½ feet high and 18 inches in diameter, are placed along the center of the top of the pier every 27 feet.

There is contained in this breakwater, according to Lieutenant Prescott's plan, 44,42[illegible] perches of stone, 25 cubic feet to a perch, or about 82,268 tons, or 41,134 cubic yards. About 5,000 cubic yards, or 10,000 tons, are above mean low water.

I estimate the cost of removing the breakwater at $2 per ton, amounting to $164,536; add 10 per cent. for contingences, &c., makes total cost of removal $180,989.60.

By running it south 65° 30′ west (magnetic) from Stonington Point, as shown on the map, the amount of stone in the present pier will build one whose top will be 7 feet above mean low water, and similar to the one now existing, excepting that the inner slope shall be one to one—950 feet long—200 feet longer than the present one. This plan may be modified if, in your opinion, necessary.

According to the above, ample anchorage-ground for the requirements of commerce will be secured.

The excess of cost of this plan over any of the others I think is compensated for by the fact that this will be a *permanent* improvement; the harbor will be increased very much in size, not only from the location of the breakwater, but from the extension of it.

It will be seen from a communication which I have appended to this report from Mr. George D. Stanton, and signed by twenty-two of the leading and most influential citizens, in answer to certain inquiries of mine relative to the improvement of the harbor, that the greatest number of vessels in the harbor in one day was one hundred and seventeen. It is very evident that in case of a storm but a very small percentage of this number could be afforded protection by the present breakwater.

Stonington is the only harbor between Newport and New London, and when improved will be of very great benefit to the coasting trade. Vessels going westward oftentimes dare not attempt the passage of the race between Fisher's and Gull Islands on account of contrary winds, stage of tide, darkness, &c., but can easily make the harbor; and in the case of vessels bound east, after passing the race, being met by northeast storms, they must either put back, stand out to sea, or make this harbor.

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I think that the protection that commerce requires from Congress would result in their making an appropriation this coming winter, for the purpose of removing this breakwater as above proposed, thereby affording more ample security to the interests of those engaged in maritime pursuits.

A jettee, with triangular section, its top on a level with high water, running from Wampasset Point to the buoy on the shoal of the same name, would break the chop-sea that comes into the harbor, produced by southwest winds; this would require only 4,500 cubic yards of stone, and would cost about $20,000. (See map.)

In connection with this report, I append statistics relative to the value of shipping, &c., compiled by Mr. George D. Stanton. Also, a paper giving the population, amount of business, &c., of Stonington. Also, an extract from Webb's Northeastern Railway Gazetteer.

I am, general, your obedient servant,

JOHN H. DAGER,
Civil Engineer.

Brevet Major-General G. K. WARREN,
Major of Engineers, U. S. A.

WARDEN'S OFFICE,
Stonington Borough, July 10, 1871.

DEAR SIR: In reply to your inquiry in relation to the improvements desired in Stonington Harbor, I have to state that I have conferred with the leading citizens, and especially the sea-captains of the town, and the following is offered as an abstract of their views on the subject: In regard to the present inadequacy of our harbor to accommodate coastwise vessels, we would state that the New York steamers which connect at this port with the Providence and Boston Railroad now require a clear channel-way from their dock of 100 feet to the end of the breakwater, which materially diminishes the anchorage capacity of the harbor, and vessels that would naturally stop here—this being the last haven west of Newport—have to make harbor at New London, and many times those vessels that arrive here have to put back to New London.

As an illustration of the importance of Stonington Harbor to the coasting trade, the following statistics are given: Number of vessels that pass this port annually, 25,000, representing in value $25,000,000; aggregate value of cargoes, $45,000,000; the amount of tonnage in this customs district, 19,000 tons, representing in value $1,550,000; annual amount of business of fishing vessels from this district, $75,000; average number of vessels making harbor here annually, 3,000; greatest number of vessels in harbor in one day, 117. With regard to the most practicable plan for increasing the commodiousness of the harbor, you, of course, are best qualified to judge. We expect it to be shown, however, by a comparison of your soundings with those of the coast survey, that the harbor north of the breakwater is rapidly filling in with deposit, and that your current observations will likewise show that this deposit is principally due to the improper location of the present breakwater. Should such prove to be the case the proper remedy will readily suggest itself to you.

To meet the growing demands of the coastwise trade there are certainly two indications to be fulfilled: 1st. The removal of the deposit by dredging; 2d. To increase the anchorage capacity of our harbor. To remove the deposit without at the same time removing the cause, would confer but a temporary benefit, and would be a useless expenditure of means. What seems to be more especially indicated is the removal in part or entire of the present breakwater, and its location to the remote end of the point. Had it been placed there originally it would have obviated the necessity for the removal of the old light-house and the construction of the present one. The location of the breakwater at that place would not only increase the anchorage capacity of the harbor many fold, but, what is of additional importance, it would also serve as a barrier against the encroachments of the sea, which is washing away the shore there at the rate of 3½ feet per annum, at which rate, in one hundred and fifty years' time, it will again be necessary to remove the present light-house farther north.

It has also been proposed to increase the capacity of the harbor by dredging that portion above the railroad dock, which, if done, will require a channel to be dredged to it from the end of the breakwater of at least 600 feet in width and 15 feet in depth at mean low water, to enable vessels to beat in and out with safety. The necessary dredging which this plan would require would probably cost not far from $100,000, and the dredging might be required to be repeated after the lapse of a few years.

It is therefore questionable whether it would be as economical in the end as the more permanent method of removing the breakwater to where it should have been located in the first place, which would answer for all time.

We wish to be distinctly understood, in asking for the improvements under con-

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sideration, that it is not for the benefit of any local interest, but for the benefit of commerce generally; that it is needed for the better protection and accommodation of thousands of vessels freighted with many millions of dollars' worth of property which pass this port annually. It has been further suggested that if a cheap sea-wall were to be constructed on Wampasset Shoal, running southeast and northwest, it would materially add to the security of vessels lying at anchor during heavy southwest winds which produce a chopping sea, and which at times is so severe as to make it necessary to change the mooring of vessels from the south to the north side of the docks. Such a work need not involve an expense of more than from $10,000 to $15,000.

Your attention is also called to the fact that at the site of the proposed new breakwater on the remote end of the point, the water is quite shoal, (6 to 8 feet,) with a firm rocky bottom, and in case of the removal of the present breakwater, it would furnish nearly sufficient material for the new one, which is not required to be constructed after such an expensive plan. According to the inspector's report, more than one-half of the vessels making harbor here anchor outside of the breakwater.

Respectfully, yours,

GEO. D. STANTON,
Warden.

J. H. DAGER, Esq.,
Civil Engineer.

The undersigned citizens of Stonington concur with the above statement:

DAVID S. HART.	THOMAS BURTCH.
NATHANIEL B. PALMER.	ELIAS CHESEBORO.
W. D. PALMER.	GEO. S. BREWSTER.
JOSEPH E. SMITH.	W. E. BREWSTER.
FRANKLIN HANCOX.	J. K. PENDLETON.
M. PENDLETON.	JOS. X. STEVENS.
H. N. TRUMBULL.	B. F. ASH.
Captain C. B. SMITH.	W. R. PALMER.
GURDON PENDLETON.	C. O. BREWSTER.
JOS. N. HANCOX.	S. SHEFFIELD.
EPHRAIM WILLIAMS.	JOSHUA HALEY, Jr.

OFFICE OF THE WARDEN.
Stonington Borough, September 27, 1871

DEAR SIR: I have obtained for you the following statistics, as requested in your favor of July 21. The total value of shipping at this port, estimated by Collector Hubbard, $750,000. This estimate does not include the whole amount for this customs district, which comprises the ports of Westerly and Mystic, but for this harbor alone. The amount of stone shipped from here is about 12,000 tons per annum. The amount of coal landed here to be sent off by rail, 15,000 tons per annum.

Yours, truly,

GEO. D. STANTON.

J. H. DAGER, Esq.,
Civil Engineer.

Stonington in 1836 contained about one hundred and fifty dwellings and stores, and had a population of 1,000. The value of business done at that time was about $[illegible] per annum. Sealing and whaling was the principal business; in some years [illegible] seal skins were brought into the place. The population in 1860 was 1,[illegible]; in 1870 1,562. The decline in population and amount of business done is owing, in a great measure, to the abandonment of the whale and seal fisheries and the general stagnation of commerce. The present amount of business is estimated at $175,000 per annum. The Stonington Steamboat Company and the Stonington and Providence Railroad Company do an annual business of $1,500,000.

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APPENDIX U.

ANNUAL REPORT OF COLONEL H. W. BENHAM, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

BOSTON, MASSACHUSETTS, *September* 10, 1872.

GENERAL: I have the honor to make the following report in relation to the sea-walls of the Great Brewster Island, of Deer Island, and of Lovell's Island, all in this harbor, for the year ending June 30, 1872:

The Great Brewster Island walls, I am gratified to be able to state, are in good condition throughout, and as they were represented last year, affording efficient protection to the bluffs of this island, while the general arrangement and direction of their terminations is such that there has been no essential abrasion to the old level drift portions of the island.

All of the buildings, (except the old boarding-house I had erected there in 1849,) together with the wood or pile portion of the wharf, have been removed for reconstruction for the uses of the batteries at Long Island Head, as previously reported.

No funds appear to be required at present, and none are now asked for this work.

As to the three sea-walls protecting the three bluffs of *Deer Island*, I would report them as in essentially good condition, especially in the parts that had been rebuilt. A few defects are found by the falling or drawing out of the foundation stones, even in some cases on the parts rebuilt, by their not having been taken up to the lowest foundation course, and by a greater force of the current or waves along these foundations than appears to have existed before, but most of them are reparable without great expense. But for the reconstruction of certain additional portions of the north head-wall with mortar and concrete backing, and providing additional stone for pile-jettees along this wall for its permanent security, (though not of immediate pressing necessity,) I would respectfully repeat the recommendation in my report of September 6, 1870, and of August 30, 1871, that there should be appropriated the sum of $18,000.

In relation to the sea-walls at *Lovell's Island*, I would respectfully report that the sea-wall on the southeast side, or on the east main bluff, erected in 1869–'70, is in as perfectly good condition as the day it was finished, as to all parts, its foundation, jettees, coping, paving, &c.; and the position and lines of the work, even with its low relief of 10 feet, including foundation, are such that there is no abrasion of the bluff in rear or at the ends, or scarcely a variation in the level of the shingle-drift of 6 inches from the joint of the two lower courses of stones above the foundation.

And I would state that the old sea-wall of Ram Head is also in good condition, in its mainly exposed part; the repairs applied to its foundation there two or three years ago appearing to answer the purpose perfectly, and except a slight displacement of the stones of the west jettee and extremity of the wall, it appears perfectly to answer its design for the protection of the remains of Ram Head. Immediately south of and adjacent to this west termination of the Ram Head wall, there is, however, the continued abrasion to the shore, as stated in my reports of September 1, 1870, and 1871. This extends now some 80 yards, with a deeply indented curve of shore-line drift, with a narrow ridge of shingle, on the

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top of which the surf-deposits of the recent storms are now resting, the sea having even passed over to flood a portion of the island between the Ram Head and main bluff. And it is obvious that any slight additional strength of the waves in a future storm might break through this ridge and force a channel entirely through at the east, between the two bluffs and the sea-walls already built, even if it did not work a passage to the southeast toward the main channel to its great injury, if not to its destruction.

In view of this danger I would respectfully repeat my recommendation for a short sea-wall, for the extension of the old wall, as also an "apron" protection still beyond it, or farther south upon the water lines of the shingle-drift, as I had made in the annual reports above referred to, for $15,000.

Respectfully submitted.

H. W. BENHAM,
Colonel of Engineers, Brevet Major-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers.

APPENDIX V.

ANNUAL REPORT OF LIEUTENANT-COLONEL GEORGE THOM, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, September 14, 1872.

GENERAL: I have the honor to submit the following reports of operations upon the works of improvement under my charge for the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

GEORGE THOM,
Lieutenant-Colonel of Engineers, Brevet Brigadier-General, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

V 1.

IMPROVEMENT OF THE NAVIGATION OF THE SAINT CROIX RIVER, ABOVE THE LEDGE, MAINE.

By an act of Congress approved March 2, 1867, the sum of $15,000 was appropriated for the improvement of this river, "provided the province of New Brunswick shall contribute and pay to the proper disbursing officer a like sum for said purpose; said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than one-half the sum actually expended for said purpose." As the co-operation of the province is yet to be obtained in this matter, operations have not been commenced.

The improvement of its navigation requires its channel to be deepened by the removal of slabs, edgings, and saw-dust, which, for thirty years

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and more, have been accumulating in large quantities from the numerous saw-mills above and near Calais.

For an accurate estimate of the "amount that is required for the entire and permanent completion" of this improvement a careful survey will be necessary. An examination made by me showed that—

To open a channel 100 feet wide, and 10 feet deep at low water, would require the removal of not less than 100,000 cubic yards of slabs, edgings, and sawdust, which, at 90 cents per cubic yard, would amount to	$90,000
Add for contingencies, say	10,000
Total	100,000
Deducting one-half paid by the province of New Brunswick	$50,000
Amount required on the part of the United States for its completion	50,000

Of this amount $25,000 could be expended to advantage upon the work during the next fiscal year.

V 2.

IMPROVEMENT OF NARRAGUAGUS RIVER, MAINE.

The following appropriations have been made for this work, viz:

By act of Congress approved March 3, 1871	$12,000
By act of Congress approved June 10, 1872	10,000
Total	22,000

The improvements of this river consist in the removal of a vast quantity of ledges and bowlders from its channel, between its mouth at Millbridge and the bridge at Cherryfield, a distance of about seven miles. In conformity with a project approved by the Department, this work has been carried on with hired labor.

On the 1st of July, 1871, more than 250 bowlders, weighing in all about 550 tons, had been removed from the channel at and above Small's Point, including one of about 80 tons, nearly opposite Dyer's wharf, and 30 others, weighing from 3 to 15 tons each. Operations were continued in 1871, until the end of October, when they were suspended until June, 1872, on account of the high stage of the river.

The following is a statement of the additional work done during the fiscal year ending June 30, 1872, viz:

		Tons.
1.	Above Dyer's wharf removed about 300 bowlders, weighing in all about	300
	Above Dyer's wharf removed ledge, weighing about	50
2.	Below Dyer's wharf removed 2 bowlders, weighing in all about	15
3.	At Snow's Rips removed 46 bowlders, weighing in all about	110
4.	At Sprague Rips and below removed 6 bowlders, weighing in all about	40
5.	Near Collins's Point and below removed 40 bowlders, weighing in all about	70
6.	Leighton's wharf removed 5 bowlders, weighing in all about	25
7.	Below Shaw's Head several bowlders, weighing in all about	15
8.	At Hinckley's ship-yard removed 29 bowlders, weighing in all about	100
9.	At Small's Point removed about 350 bowlders, weighing in all about	225
10.	Above the falls removed about 33 bowlders, weighing in all about	60
11.	At the falls removed about 220 bowlders, weighing in all about	60
	At the falls removed a ledge weighing about	1,000
12.	Below the falls removed about 75 bowlders, weighing in all about	200
13.	Near Fickett's wharf at Millbridge removed 4 bowlders, weighing in all about	10

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From which it appears that, since July 1, 1871, there have been removed from the bed of the river over 1,100 bowlders of various sizes, weighing in all about 1,200 tons, and of ledge at the falls about 1,000 tons.

Previous to July 1, 1871, there were also removed, as above stated, more than 250 bowlders, weighing in all about 550 tons. Total quantity of rock removed to June 30, 1872, about 2,750 tons.

Amount appropriated by act of March 3, 1871, as above	$12,000 00
Expended up to July 1, 1871	1,904 59
Available July 1, 1871	10,095 41
Expended in the fiscal year ending June 30, 1872	8,335 [illegible]
Available July 1, 1872	1,760 [illegible]
Appropriated by act of June 10, 1872	10,000 00
Total amount available July 1, 1872	11,760 [illegible]

The work already done has greatly improved the navigation of this river, so much so that, during the last year, coasting-vessels of light draught, with center-boards, have been built and are now running to and from Cherryfield without the necessity of "scowing" down to Mill bridge and transshipping there, which they have hitherto been obliged to do.

The balance available for this work on the 1st of July, 1872, will be sufficient to complete all the improvements at present contemplated.

V 3.

IMPROVEMENT OF SULLIVAN RIVER AND SULLIVAN FALLS, MAINE.

This river is navigable from its mouth up to Franklin, a distance of about nine and one-half miles, and the only obstructions to its navigation are Hatcher's Rock and a point of ledge in the falls, and the foundation of the bridge piers about one mile above the falls.

The following appropriations have been made for this work, viz:

By act of Congress approved March 3, 1871	$10,000 00
By act of Congress approved June 10, 1872	25,000 00
Total	35,000 00

Under the appropriation of March 3, 1871, a contract was made on the 8th of May, 1871, with Mr. George W. Townsend, of Boston, Massachusetts, the lowest bidder, at $35 per cubic yard, for removing 270 cubic yards of Hatcher's Rock, as stated in my last annual report. The contractor commenced work about the 1st of June and removed about 130 cubic yards during that month, that is, up to the end of the fiscal year ending June 30, 1871. Operations were continued by him until the 1st of August, 1871, at which time he had removed over 270 cubic yards in completion of his contract. By this work the appropriation of March 3, 1871, was entirely exhausted.

The channel has thus already been much improved in the "falls," it having an increased depth of 4 feet over Hatcher's Rock, it now having 3½ feet of water on it at mean low water, or 11½ feet at mean high water, which is sufficient (in high water) for most of the vessels now navigating this river.

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Amount available for this work July 1, 1871, $9,773.03, which was all expended during the fiscal year ended June 30, 1872. Amount available for the work July 1, 1872, $25,000, being the amount appropriated by act of June 10, 1872.

The following is an estimate of the cost of the work still contemplated to be done, viz:

1. Removing remaining portion of Hatcher's Rock to a depth of 9 feet below mean low water, 380 cubic yards, at $35*	$13,300 00
2. Removal of a portion of ledge near Hatcher's Rock to a depth of 7 feet below mean low water, 24 cubic yards, at $35*	840 00
3. Removal of two stone-bridge piers, at $3,000* each	6,000 00
4. Iron spindle on Half-Tide Ledge and Low-Water Rock, at $1,250 each	2,500 00
Add for contingencies, say	2,360 00
Total	25,000 00
Amount available July 1, 1872	$25,000 00

No further appropriation will, therefore, be required for the contemplated improvements in this river and in the "falls."

V 4.

IMPROVEMENT OF UNION RIVER, MAINE.

Under the appropriation of $15,000 made by act of Congress approved July 11, 1870, a contract was made on the 10th of September, 1870, with Messrs. Morris & Cumings, of New York City, for opening a channel 150 feet in width, through the slabs, edgings, and sawdust, down to the natural bed of the river, between the wharves at Ellsworth and the head of the narrows, a distance of about half a mile, for the sum of $12,000. Work was commenced under this contract on the 19th of September, and continued up to the middle of December, when it was suspended on account of the ice. It was resumed by them about the 20th of April, 1871, and continued until the 13th of September, 1871, when the contract was completed. Up to July 1, 1871, about 40,000 cubic yards of slabs, &c., had been removed by contract. Twenty-four bowlders (each weighing from 3 to 45 tons) had been removed from the channel above Fullerton's Point, and about 150 tons from the channel at the mouth of the river, with hired labor. Since the 1st of July, about 30,000 cubic yards of slabs, edgings, &c., have been removed by the contractors, making a total of about 70,000 cubic yards removed under their contract. After this the dredging operations were carried on, up to the 2d of November, by day's work, the work done having been confined to that part of the river in front of the wharves at Ellsworth. Here the channel was very much improved in being widened and deepened by the removal of a great number of large bowlders, as well as of slabs and edgings.

The submarine party, which was employed by the day in removing sunken rocks from the channel at the mouth of the river, continued work until the 1st of September, 1871, having been employed thereon since the 16th of June, 1871. This submarine party has, since the 1st of July, 1871, broken up and removed about 520 tons of ledge and bowlders lying in the eastern channel at the mouth of the river, in addition to which, during the same period, there have been removed with other

*The prices as contracted for, August 26, 1872, with Mr. George W. Townsend, of Boston, Massachusetts.

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hired labor over 300 tons bowlders lying in the bed of the river between Fullerton's Point and the head of navigation, as well as a wreck lying in the channel nearly opposite Tinker's wharf.

Several spar-buoys have also been placed to mark the new (eastern) channel, recently opened at the mouth of the river, and a large wrought-iron 14-inch spindle has been purchased, to be placed on Fullerton's Point, and the hole for its reception has been partially sunk into the ledge. It was intended to place this beacon* in position before the close of navigation in 1871, which probably would have been done had not the river been closed with ice some two or three weeks earlier than usual, causing a suspension of the work.

The appropriations made for this work are as follows, viz:

By act of Congress approved July 11, 1870	$15,000 00
By act of Congress approved March 3, 1871	15,000 00
Total	30,000 00
Amount available July 1, 1871	$26,186 62
Amount expended during fiscal year ending June 30, 1872	25,576 56
Amount available July 1, 1872	609 46

which amount will be sufficient to complete the work upon the iron beacon on Fullerton's Point, all that now is contemplated for completing the improvement of this river.

The work thus far done for the improvement of this river consists—

1. In opening a new navigable channel into the river at its mouth, by the removal of a large quantity of sunken ledges and bowlders, which have heretofore rendered the navigation very unsafe and, indeed, impracticable, as well as the removal of several large bowlders lying upon the bar at its mouth, and in marking out this new channel with large spar-buoys, thereby affording a good, safe channel, having 4 to 5 feet of water at mean low water, or 16½ feet at ordinary high water.

2. The removal of over 500 tons of bowlders and of 75,000 to 80,000 cubic yards of slabs, edgings, &c., from the channel of the river, from its mouth up to the head of navigation at Ellsworth, thereby opening a good and safe channel about 150 feet in width, with 3 to 4 feet of water at mean low water (or 15 feet at mean high water) in low stages of the river.

These improvements comprise all that were originally contemplated, and for which estimates were submitted in my report dated September 10, 1870.

No further appropriation is required.

V 5.

IMPROVEMENT OF PENOBSCOT RIVER, MAINE.

The navigation of this river is much obstructed by bars and sunken rocks, between Bangor and Crosby's Narrows, about three and a half miles below. These bars are for the most part composed of the "waste" from the saw-mills at Bangor and above, which has been accumulating, to a vast extent, for more than fifty years.

The sunken rocks are all in the harbor of Bangor, and are known as "Independence Rock," "Steamboat Wharf Ledge," "Gulliver's Rock," "Green's Pier Ledge," and others.

* This beacon was completed in the latter part of August, 1872.

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The contemplated improvements of this river comprise the enlarging and straightening of its channel, through the bars, to a width of not less than 200 feet, and a depth of 12 feet below low water in the lowest stages of the river; and the breaking up and removal of the ledges at Bangor, down to the general bed of the river, so as to obtain 7 feet of water in the same stages of the river.

The following appropriations have been made for this work, viz:

By act of Congress approved July 11, 1870	$15,000 00
By act of Congress approved March 3, 1871	50,000 00
By act of Congress approved June 10, 1872	40,000 00
Total	105,000 00
Up to July 1, 1871, there had been expended on this work	$7,559 37
And during the fiscal year ending June 30, 1872	39,781 00
Total expended up to July 1, 1872	47,340 37
Unexpended July 1, 1872	$57,659 63

On the 27th of May, 1871, a contract was made with Mr. A. Boschké, of Boston, Massachusetts, (the lowest of three bidders,) for excavating a channel through the three principal bars, at Bangor and below, as follows, viz:

1. Through "Upper Bar," extending down to Low's Ledge, to a width of 200 feet, for	$18,320 00
2. Through "Middle Bar," lying between Crosby's ship-yard and Blunt & Co.'s steam saw-mill for	7,400 00
3. Through "Lower Bar," near Stearn's mill, for	3,375 00
Total	29,095 00

On the 19th of June Mr. Boschké commenced operations at the Upper Bar, and on the 1st of July the work on that bar was about one-eighth finished, and on the 13th of October it was entirely finished.

On the 21st of October he commenced operations on the Middle Bar and continued up to the 4th of November, when work had to be suspended on account of the freshet in the river, the work on this bar then being about one-tenth done. Operations were resumed early in June, 1872, and at the close of the fiscal year about one-sixth of the work required on this bar had been done.

The work on the sunken ledges in the harbor of Bangor, which was resumed on the 3d of June, 1871, was continued up to the 17th of October, 1871, when it was suspended on account of the freshet. Up to the 1st of July the quantity of ledge broken up and removed was as follows, viz:

Removal from Steamboat Wharf Ledge about 400 tons, and from Independence Rock 80 tons. Since the 1st of July the following additional work has been done:

	Tons.
1. Removal from Steamboat Wharf Ledge, about	600
2. Removal from Independence Rock, about	800
3. Gulliver's Rock, wholly removed, containing about	80
4. Green's Pier Ledge, removed to bed of river, about	115
Quantity removed since July 1, 1871	1,595
Quantity removed up to July 1, 1871	480
Quantity removed up to July 1, 1872	2,075

or about 1,000 cubic yards.

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There yet remains to be done for the removal of all these ledges down to a depth of 7 feet below mean low water, in the lowest stages of the river, 530 cubic yards, the cost of which, at $40 per cubic yard,* (the price contracted for,) will be	$21,200 00
Amount required to meet the contract made with Mr. Boschké, including the percentage retained up to July 1, 1872, is	14,587 00
Total	35,787 00
Unexpended July 1, 1872, as above	57,659 53
Leaving a balance of	21,872 53

which is to be applied to enlarging still more the channels through the bars below Bangor.*

It is recommended that no further appropriation be made for the improvement of this river, until the throwing of *sawdust* into it (which is still continued to a very great extent, to the great detriment of its navigation) shall be prevented by suitable legislation.

V 6.

IMPROVEMENT OF KENNEBEC RIVER, MAINE.

The following appropriations have been made for this work up to July 1, 1871, viz:

1. By act of Congress approved June 23, 1866	$20,000 00
2. By act of Congress approved March 2, 1867	30,000 00
3. Allotted under act of Congress approved April 10, 1869	15,000 00
4. By act of Congress approved July 11, 1870	15,000 00
5. By act of Congress approved March 3, 1871	15,000 00
Total	95,000 00

The projected work for improving the navigation of this river consists in straightening and deepening its channel, by dredging, through the several shoals, (six in all,) and the removal of all ledges and bowlders which obstruct its navigation between Richmond and Augusta.

From June 23, 1866, up to July 1, 1871, there had been appropriated by Congress, for this purpose, the sum of	$95,000 00
And the unexpended balance available therefor, July 1, 1871, was	$14,741 00
Of which amount there was applicable to the improvement of the river between Richmond and Gardiner, the sum of	4,977 27
And the balance to the river above Gardiner	9,763 73

On the 1st of July, 1871, the following work had been done, viz:

1. A channel excavated, by contract, through Hinckley's Shoal, between Gardiner and Hallowell,) to a width of 100 feet and a depth of 7 feet at low water, in the lowest stages of the river.

2. A channel excavated, by contract, through Shepard's Point Shoal and Hallowell Shoal, to a width of 75 feet and to a depth of 7 feet at low water, in the lowest stages of the river.

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* Proposals were received on the 17th of August, 1872, for the removal of the ledges at $40 per cubic yard, and a contract was made at that price; at the same time proposals were received for the dredging, at 70 cents per cubic yard, as measured in the bed of the river.

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3. A channel excavated, by contract, through Brittz's Shoal and Gage's Shoal (both above Hallowell) to a width of 100 feet and a depth of 6½ feet at low water, in the lowest stages of the river.

4. More than 130 bowlders, varying from one-fourth of a ton to 20 tons in weight, removed, with hired labor, from the bed of the river between Hallowell and Augusta. And,

5. On the 9th of May, 1871, a contract was made with Mr. Augustus R. Wright, of Geneva, New York, at 40 cents per cubic yard, as measured in the scows, for increasing, to 100 feet, the width of the channel, (previously dredged to a width of 75 feet,) through Shepard's Point Shoal and Hallowell Shoal. And on the 1st of July 974 cubic yards had been dredged from Shepard's Point Shoal under that contract.

On the 13th of September Mr. Wright completed the work called for by his contract of May 9, 1871, under which he had dredged, since July 1, 20,888 cubic yards, making a total under that contract of 21,862 cubic yards. Several large bowlders have also been removed, by hired labor, since the 1st of July, from the channels through Shepard's Point and Hallowell Shoals. By these operations all the projected improvements between Gardiner and Augusta have been completed, giving a channel not less than 100 feet in width and 6½ feet in depth at low water, (or 11 feet at high water,) in the lowest stages of the river, from Gardiner to Augusta. By these improvements, vessels drawing 10 feet of water have, for the first time, in low stages of the river, ascended (at high water) up to Augusta.

The project submitted by me, May 16, 1871, and approved by the Department, for the improvement of the river from Gardiner down to Richmond, under the appropriation of March 3, 1871, viz, $5,000, applicable to that part of the river only, embraced the following work, viz:

1. Removing the sunken rock lying in the channel near Nehumkeg Island, to a depth of 12 feet at mean low water, giving 17½ feet at mean high water, and dredging a channel through the Upper Sands Bar to a width of 100 feet and a depth of 10 feet at mean low water, or 15½ feet at mean high water. Separate proposals were invited for these two works, and on the 13th of July a contract was made with Mr. George W. Townsend, of Boston, Massachusetts, (the lowest of five bidders,) for removing Nehumkeg Rock, for $30 per cubic yard; and another contract, on the 18th of July, with Mr. Augustus R. Wright, of Geneva, New York, (the only bidder for the work,) for dredging the channel through the Upper Sands Bar, at 50 cents per cubic yard, as measured in the scows. Under these contracts the rock at Nehumkeg Island was broken up and removed to a depth of 12⅔ feet at mean low water, in the month of September, 1871, at a cost of $600; and in the month of October, 1871, the channel was completed through the Upper Sands Bar to a width of 100 feet and a depth of 10 feet, at mean low water, by the excavation of 7,578 cubic yards.

The unexpended balance on hand July 1, 1872, of the appropriations made prior to July 1, 1871, was	$286 53
By act of Congress, approved June 10, 1872, there was appropriated, for the further improvement of this river, the sum of	8,000 00
Making available therefor, July 1, 1872	8,286 53

This amount is to be applied as follows, viz:

1. To the excavation of a channel through the bar at the head of Swan Island, to a width of 100 feet and a depth of 10 feet at mean low water, requiring about 10,000 cubic yards of dredging, the estimated cost of which, at 50 cents, is	$5,000 00

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2. The removal of several bowlders from the channel at Gardiner, the estimated cost of which is	$800 00
3. Contingencies, say	986 53
Total	$6,786 53
Leaving a balance of	1,500 00

available for its further improvement.

Recent surveys, made at the Narrows in the main channel of the river east of Swan Island and a short distance below Richmond, show the existence of two ledges, which render the navigation exceedingly difficult and dangerous. Of those the western one, known as Half-tide Rock, was several years since partially removed, so as to afford a depth of 9 feet only at mean low water. But the present commerce of the river requires the reduction of both ledges to a depth of 12 feet; to do which would necessitate the removal of 350 cubic yards—

The estimated cost of which, at $35 per cubic yard, is	$12 250
Contingencies, say	1,250
Total	13,500
Balance of appropriation June 10, 1872, available for this work	$1,500
Additional amount required for completing the improvement of this river below Richmond	12,000

which amount could be profitably expended thereon during the next fiscal year.*

V 7.

IMPROVEMENT OF THE NAVIGATION OF THE GUT OPPOSITE BATH, MAINE.

The work originally projected for the improvement of this place consisted in—

1. The removal of Boiler Rock to a depth of 10 feet at mean low water, or 16½ feet at mean high water;
2. The removal to a depth of 9 feet at mean low water of the ledge extending from Boiler Rocks northward toward the shore;
3. The removal of two wrecks of vessels lying in mid-channel above and near "Upper Hell Gate;"
4. Dredging a channel through the bar next above "Upper Hell Gate," to a width of 100 feet and a depth of 10 feet at mean low water, or 16½ feet at mean high water;
5. Removing points of ledge which project into the river from its southern bank at the "Upper Hell Gate," so as to increase the waterway and thereby diminish the velocity of the current.

On the 1st of July, 1872, all this work had been completed, with the exception of the removal of the points of ledge at the "Gate," and of this about 250 cubic yards had been blasted off and removed.†

Amount appropriated for this work up to July 1, 1871	$16,500
Amount available July 1, 1871	2,937
Amount available July 1, 1872	2,000

No further appropriation is required for this work.

* On the 20th of August, 1872, a contract was made with Mr. Augustus R. Wright, Geneva, New York, for this dredging, at 50 cents per cubic yard, which will probably be completed about the 1st of October, 1872.

† This work was all completed in September, 1872, by the removal of about 300 cubic yards of ledge.

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V 8.

IMPROVEMENT OF ROYALS RIVER, MAINE.

This improvement consists—

1. In the enlargement of the channel through the bar at Gravel Point to a width of 100 feet and a depth of 5 feet at mean low water, so as to give 14½ feet at ordinary high water, up to the head of navigation at the wharves of Yarmouth; and

2. In the blasting and removal of the several ledges above and near Brown's wharf, known as "Call 'em Point Ledge," "Big Rocks," and "Little Rocks."

By act of Congress approved March 3, 1871, there were appropriated for this work	$10,000 00
And by act of June 10, 1872	10,000 00
Total	20,000 00

On the 26th May, 1871, a contract was made with Mr. W. R. Stockbridge, of Boston, Massachusetts, (the lowest of five bidders,) for the dredging required on the "Gravel Point Bar," at 49½ cents per cubic yard, measured in the scows. This work was not commenced until the 16th of September, owing to many difficulties which the contractor had in procuring his machinery for it. Very unsatisfactory progress was afterwards made, in consequence of which the contractor discontinued operations on the last of October, after having executed but 2,945 cubic yards, and thereby leaving the work not more than one-fifth done. The contract required the work to be *completed* on or before the 15th of November, 1871.

The contractor having then abandoned the work, it was decided that the retained percentage, amounting to $291.55, should be forfeited to the Government, and that proposals should be again invited for this work.

In response to an advertisement dated March 12, 1872, inviting proposals for completing the dredging, two bids were received, the lowest being that of Mr. Augustus R. Wright, of Geneva, New York, at 49 cents per cubic yard. On the 23d of April a contract was made with Mr. Wright for 15,000 cubic yards, more or less, of dredging, to be completed on or before the 15th of September, 1872. On the 30th of June, 1872, 6,018 cubic yards had been dredged on this contract.*

Amount available for this work July 1, 1871, was	$9,818 23
Amount expended during fiscal year ending June 30, 1872	4,477 31
Amount available July 1, 1872, (including the appropriation of $10,000 made by act of June 10, 1872)	15,340 92
Of this amount there will be required to pay for the work to be done under the existing contract with Mr. Wright, say	4,340 92
Which will leave available for the removal of the ledges	11,000 00

which amount is deemed sufficient for the purpose.

No further appropriation is therefore recommended for the improvement of this river.

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* This contract was satisfactorily completed on the 15th of August, under which 13,782 cubic yards of dredging was done.

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V 9.

IMPROVEMENT OF PORTLAND HARBOR, MAINE.

The following appropriations have been made for the improvement of this harbor, viz:

By act of June 23, 1866, the sum of	$105,111 65
By act of June 11, 1870, the sum of	10,000 00
By act of March 3, 1871, the sum of	40,000 00
By act of June 10, 1872, the sum of	45,000 00
Total	200,111 65
Amount available July 1, 1871	$89,649 00
Amount expended during the fiscal year ending June 30, 1872, (including that due on retained percentage)	36,311 26
Amount available July 1, 1872, (including the appropriation of June 10, 1872)	53,337 74

Up to the 1st of July, 1871, the following work had been done for the improvement of this harbor, viz:

1. The unfinished capping of the breakwater completed for a length of 733½ feet;

2. A channel dredged through the spit opposite the Grand Trunk Railway wharves, so as to be 100 feet in width at its inner end and 200 feet at its outer end, with a depth of 20 feet at mean low water; and

3. A channel dredged through the "Middle Ground Bar" to a width of 300 feet and a depth of 21½ feet at mean low water, giving a depth of about 31 feet at ordinary high water into the inner harbor of Portland.

4. On the 24th May, 1871, a contract was made with Mr. George C. Fobes, of Portland, for completing the channel through the "Middle Ground Bar" to a width of 500 feet for the price of 45 cents per cubic yard, a work requiring about 80,000 cubic yards of dredging.

On the 1st of July, 1872, 71,397 cubic yards of dredging was done under this contract, nearly reaching its completion. This contract was satisfactorily completed on the 15th of July, 1872, with 78,400 cubic yards of dredging.

In conformity with a project which has received the approval of the Department the balance of the appropriation available for this harbor will be applied to the completion of the breakwater by extending it outward for a distance of about 200 feet, and building at its outer end a substantial pier for the foundation of a light-house.

The probable cost of which will be about, (as contracted for)	$20,000 00
To which add the amount required for completing dredging, with contingencies, say	3,337 74
Total	23,337 74
Amount available July 1, 1872, (as above)	53,337 74
Leaving available for otherwise improving this harbor, including Back Bay, as provided for by act of June 10, 1872	25,000 00

The work to be done in "Back Bay" consists in enlarging its channel to an extent requiring not more than 40,000 cubic yards of dredging, the estimated cost of which, at 25 cents per cubic yard, (the price contracted for,) is $10,000.

The amount now available for this harbor is sufficient for completing

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all the contemplated improvements, so that no further appropriation is now recommended to be made.

These works are situated in Portland Harbor, in the collection district of Portland and Falmouth.

The amount of revenue collected at the port of Portland for the fiscal year ending June 30, 1872, was, as stated by the United States collector of customs, as follows, viz:

Duties on importations	$562,107 07
Tonnage duties	15,805 20
Total	577,912 27

Duties assessed, (which more properly show the business of the port)	$11,830,781 18
Value of imports	21,955,803 00

Accompanying this is a map of the harbor as recently surveyed, showing the present channel over the "Middle Ground Bar" as completed.

V 10.

IMPROVEMENT OF RICHMOND'S ISLAND, MAINE.

The work for the improvement of this place consists in the building of a stone breakwater along the shoal which connects the island with the main-land, so as to form a good harbor of refuge, with safe anchorage and good holding-ground, with the wind from any point between the north and southwest. As the winds from the northward and eastward bring the most violent and destructive gales which occur on this coast, there can be no question as to the great benefit to be derived from such a work at this place, in affording refuge to vessels which are prevented by these storms from entering Portland Harbor (twelve miles to the eastward) or other places on this part of the coast.

The average length of the proposed breakwater is 2,000 feet, with an average thickness of 30 feet, and a height of 13 feet. As a capping for this work would greatly increase its cost, it is not now estimated for. But should it, hereafter, be found necessary, which is not probable, to resist the action of the sea, it can be added.

To thus construct this work would require about 60,000 tons of rubble-stone, the estimated cost of which, at $1.24 per ton, is	$74,400 00
Adding for contingencies, say	5.600 00
Total	80,000 00

By act of Congress approved June 10, 1872, there was appropriated for this work the sum of	$20,000 00
So that there will be required for its completion an additional appropriation of	60,000 00

all which could be profitably expended upon the work during the next fiscal year.

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V 11.

IMPROVEMENT OF SACO RIVER, MAINE.

The several appropriations and allotments that have been made for improving the navigation of this river up to July 1, 1871—

Amount to	$147,500 00
Amount appropriated by act of June 10, 1872	15,000 00
Total	162,500 00
The unexpended balance available therefor July 1, 1871, was	$11,919 92
Amount expended during the fiscal year ending June 30, 1872	11,071 39
Balance available July 1, 1872, including the appropriation made by act of June 10, 1872	$15,839 53

The work done up to the 1st July, 1871, consisted in the removal of all the sunken rocks and ledges which obstructed the channel near Little Island; and in partial completion of the breakwater at the mouth of the river 72,776$\frac{380}{2240}$ tons of rubble-stone had then been placed upon it, under five separate contracts, with which the breakwater had been partially completed to a length of 4,200 feet.

Under the contract made on the 9th May, 1871, with Messrs. Gooch & Haines* 3,264$\frac{1640}{2240}$ tons had been furnished by them, up to the 1st of July, 1871, and 4,008$\frac{80}{2240}$ tons more between July 1 and August 15, 1871, making altogether 7,272$\frac{1720}{2240}$ tons furnished by them in completion of their contract, which was all applied to increasing the breakwater in height and thickness. The total quantity of stone, therefore, that has been delivered upon the breakwater up to June 30, 1872, is 76,774$\frac{460}{2240}$ tons, or 85,987$\frac{220}{2000}$ net tons. With this the breakwater has been built to a length of 4,200 feet, and to a height of 10 feet above mean low water, with an average thickness of about 20 feet. The effect of this breakwater in opposing the movement of the sand into the river from the beach to the northward of it has been such that the sand has accumulated for an extent of several acres on its northern side, some three or four hundred feet of the shore-end of the breakwater being already buried up by it. Upon this sand beach-grass has been planted, (during the past year,) in order to check the further movement of the sand toward the river, which it is believed will be entirely effectual.

The following additional work has also been done since July 1, 1871, viz:

1. A large wrought-iron spindle, 20 feet long and 14 inches in diameter, surmounted with an iron "day-mark," 8 feet in height, has been placed on the foot of the ledge below Cow Island, to serve as a beacon for that locality; and

2. A channel has been excavated, with machinery hired by the day, through the bars, below the wharves at Saco and Biddeford, to a depth of 5 feet below mean low water, in low stages of the river, giving 13 feet at ordinary high water, and by an average width of about 50 feet. About 4,000 cubic yards of material (including a large quantity of logs, slabs, &c.) were excavated and removed from these bars. This work was suspended on the 1st of December, on account of the river being closed by ice some two or three weeks earlier than usual.

* Messrs. Gooch & Haines were the lowest of three bidders, the stone being furnished by them at $1.10 per ton of 2,240 pounds, the lowest price for which stone has ever been furnished for this work.

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By the work already done the navigation of this river has been vastly improved, from its mouth up to the head of navigation, at Saco and Biddeford, a distance of five miles.

1. The channel at its mouth has been straightened, and so deepened by the construction of the breakwater that vessels can now cross the old spit and carry 6 feet, at mean low water, or 14¾ feet at ordinary high water, directly up to the beacon, and thence enter the river with 4 feet at mean low water, or 12¾ feet at ordinary high water. The surveys that have been made every year since the commencement of this breakwater have shown a continual improvement in the channel both in direction and depth.

2. The dangerous ledges have been removed from the middle of the very narrow channel near Little Islands.

3. An iron beacon has been placed to mark the foot of Cow Island Ledge.

4. A practicable channel, having 5 feet of water at mean low water, or 13¾ feet at ordinary high water, has been partially excavated to a width of 50 feet through the bars, below the wharves of Saco and Biddeford, thereby giving an increased depth of 3 to 4 feet, and enabling vessels drawing 13 feet of water to ascend to these wharves in low stages of the river.

The work that remains to be done for completing all the contemplated improvements of this river is as follows, viz:

1. The repair of pier (No. 8) at the "Narrows," the estimated cost of which is	$2,000 00
2. Building a stone pier on Jordon's Point in place of old pier No. 9, (destroyed)	6,000 00
3. Increasing the height and thickness of the outer end of the breakwater, (say)	6,000 00
Contingencies, (say)	1,829 53
Total	15,829 53

which amount is the unexpended balance of the appropriations now available. No further appropriation, therefore, will be required for the improvement of this river.

The works for the improvement of the navigation of Saco River are situated in the collection district of Saco, near the ports of Saco and Biddeford. The nearest light-house is on Wood Island, opposite the mouth of Saco River, and the nearest forts are those in Portland Harbor, about fifteen miles distant.

The amount of revenue collected at Saco, the port of entry, during the fiscal year ending June 30, 1872, as furnished by the United States collector of customs, was $53.10. The number of sea-going vessels which arrived during the same period was 219.

V 12.

IMPROVEMENT OF KENNEBUNK RIVER, MAINE.

The following appropriations have been made for the improvement of this river, viz:

By act of Congress approved July 11, 1870	$5,000 00
By act of Congress approved March 3, 1871	5,000 00
Total	10,000 00
Amount available for the work July 1, 1871	$5,008 84

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The projects for the improvement of its navigation under these appropriations embraced—

1. The construction of two stone piers as wings to those already built, on each side of the river at its mouth, and in place of the wooden catch-sands, which have been entirely carried away by storms, the object of which being to prevent the sand from being washed into the channel;

2. The repair of the Government wharf above the mouth of the river; and

3. The repair of the old piers.

On the 1st of July, 1871, the following work had been done, viz:

The stone pier on the eastern side of the river was completed for a length of 168 feet, and repairs made upon the main (eastern) pier, and upon the Government wharf above it; a contract had also been made (May 5, 1871) with Mr. Charles H. Bragdon, of Biddeford, Maine, for the extension of the stone pier on the western side of the river, he being the lowest of four bidders for the work, at $18.62 per linear foot; and under this contract several cargoes of stone had been delivered preparatory to commencing its construction.

The work done during the fiscal year ending June 30, 1872, is as follows:

On the 15th August, 1871, the western wall was completed to an extent of 166⅔ linear feet, in full and satisfactory completion of the contract. Repairs were made, both on the old eastern and western piers, as well as upon the Government wharf.

Amount available for this work July 1, 1871	$5,008 84
Amount expended during the fiscal year ending June 30, 1872	4,666 77
Amount available July 1, 1872	342 07

which has since been expended in additional repairs upon the piers and wharf, and in full completion of all the contemplated improvements.

No further appropriation is required.

V 13.

IMPROVEMENT OF WELLS HARBOR, MAINE.

A survey of this harbor made in 1871 showed that some thirty or forty years ago a pier of crib-work, ballasted with stone, had been built at the mouth of the harbor with a view to straightening and deepening the channel over the bar at this place. This crib-work is about 250 yards in length, but is somewhat out of repair.

By act of Congress, approved June 10, 1872, an appropriation was made for its repair amounting to $5,000.

A project for doing this work with hired labor and with materials purchased in open market has been approved by the Department, and work will be commenced upon it at as early a day as practicable.

No further appropriation is recommended for this work.

V 14.

IMPROVEMENT OF COCHECO RIVER, WITHIN THE TOWN OF DOVER, NEW HAMPSHIRE.

This river is navigable by vessels drawing 6 feet of water at mean low water, or 13½ feet at ordinary high water, (in low stages of the

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river,) as far up as the Lower Narrows, which point is one and one-half miles below the bridge at Dover, and one mile below the packet landing. At the Lower Narrows and above it, navigation has hitherto been obstructed by ledges and shoals having not more than 1 to 2 feet of water at mean low water, and not exceeding 8 feet at ordinary high water. The improvements proposed for this river consist in excavating a channel through these ledges and bars to a depth of 4 feet at mean low water, so as to give 10½ feet at ordinary high water, in low stages of the river. For this work the following appropriations have been made by Congress, viz:

By act of March 3, 1871	$10,000
By act of June 10, 1872	10,000
Total	20,000

Under the appropriation of March 3, 1871, a contract was made with Messrs. Morris & Cumings, of New York City, (the lowest of four bidders,) for opening a channel through the ledge at the Lower Narrows to a width of 75 feet and a depth of 4 feet at mean low water, for the sum of $7,000. This work was commenced in the latter part of June, 1871, and was completed on the 2d of October, in a very satisfactory and thorough manner. On the 3d of October, work was commenced with hired labor, under authority from the Department, in the removal of the sunken bowlders from the bed of the river between the Lower and Upper Narrows, (including Watson's Rock,) as well as several large bowlders below the Lower Narrows. The operations were continued until the 1st of December, when the river was closed by ice. All the sunken bowlders were thereby removed below the Upper Narrows (including those on Trickey's Shoal and Clements's Point Shoal) as far down as Dover Point, five miles below Dover; at Dover Point there still remains a large dangerous rock in mid-channel which should be taken out.

In the months of October and November, 1871, an accurate hydrographic survey was made of the river, from the Lower Narrows up to the mills at Dover, a map of which was sent to the Department, with project of the 25th of June, 1872.

During the fiscal year ending June 30, 1872, there has been expended on this work the sum of $9,063.70, leaving available a balance of $10,936.30.

The following is an estimate (based on the recent survey) of the proposed work yet to be done for the improvement of this river, viz:

1. At Upper Narrows or Gulf, excavating and removing ledge so as to have a channel 40 feet in width and 4 feet in depth at mean low water, 1,000 cubic yards, at $20	$20,000 00
2. Trickey's Shoal, dredging a channel to a width of 75 feet and a depth of 4 feet below mean low water, 1,500 cubic yards, at 75 cents	1,125 00
3. Clements's Point Shoal dredging a channel to same width and depth as at Trickey's Shoal, 1,000 cubic yards, at 75 cents	750 00
4. Excavating channel above the Gulf, 6,500 cubic yards of soft clay and sand, at 60 cents	3,900 00
5. Removing sunken rock at Dover Point to a depth of 12 feet below mean low water, 160 cubic yards, at $25 per cubic yard	4,000 00
Add for contingencies, say	3,161 30
Total	32,936 30
Unexpended balance available July 1, 1872	10,936 30
Additional amount required for completing all the contemplated improvements for this river	22,000 00

This amount could be profitably expended during the next fiscal year.

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V 15.

IMPROVEMENT OF MERRIMAC RIVER, MASSACHUSETTS.

The following appropriations have been made by Congress for this work, viz:

By act of July 11, 1870, the sum of	$25,000
By act of March 3, 1871, the sum of	25,000
By act of June 10, 1872, the sum of	25,000
Total	75,000

Of this sum $25,000 has been applied both to the partial improvement of the harbor of Newburyport, Massachusetts, and deepening the channel through the Lower Falls above Haverhill, while the remaining $50,000 has been made by law applicable only to the improvement of the river above Haverhill.

On the 1st of July, 1871, the following work had been done, viz:

1. The Main Gangeway Rock was broken up and removed to a depth of 9½ feet at mean low water, and a commencement made upon the removal of North Gangeway Rock;

2. The removal of the wreck of the schooner Globe completed; and

3. Four hundred and seventy-five cubic yards of material removed from the channel in the Lower Falls, above Haverhill.

4. Under the appropriation made by act of March 3, 1871, (which, by the act, had to be applied exclusively to the improvements above Haverhill,) proposals were invited for continuing the dredging at the Lower and Upper Falls to a width of 60 feet and a depth of 4 feet at mean low water; and on May 31, 1871, I made a contract with Mr. W. S. Fretch, of Boston, Massachusetts, (the lowest of three bidders,) for doing the work at $10 per cubic yard to the extent of the funds available therefor.

On the 1st of August, 1871, the dredging was commenced by the contractor at the Lower Falls, and on the 11th of October following he had removed 2,100 cubic yards in completion of his contract. In addition to this, a sunken ledge, which extends directly across the river at these falls, has been partially broken up (with hired labor) ready for removal.

The work done up to the 1st of July, 1872, for the improvement of this river above Haverhill consists in the excavation of a channel to a width of 60 feet, in the lower portion of the falls, up to where crossed by the sunken ledge, the partial breaking up of the ledge, and some dredging in the channel above the ledge, so that the work in the Lower Falls may now be considered as about one-half completed, but not so as to give a continuous channel of the required depth through the entire length of the falls. Finding during the progress of the work that additional surveys would be necessary for its proper prosecution, I had, with the approval of the Department, an examination made of the river from the foot of Hazeltine Rapids up to Lawrence, (a distance of seven and one-fourth miles,) and an accurate survey made of the several rapids and shoals requiring improvement. This survey shows that the amount of work required for improving the navigation of this river in the manner hitherto contemplated, greatly exceeds the estimates which others have heretofore made for it. The drawings and report on this survey were forwarded to the Department February 3, 1872.

The following is an amended estimate of the cost of the improvements

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originally contemplated, both in the harbor of Newburyport and in the falls above Haverhill, viz:

1. Completing the removal of North Gangeway Rock, in Newburyport harbor, 700 cubic yards, at $20	$14,000 00
2. Removing the "boilers" near the city wharves in Newburyport Harbor	6,000 00
3. Excavating a channel, 60 feet in width and 4 feet in depth, at mean low water at Hazeltine Rapids, 1,900 cubic yards, at $5*	9,500 00
4. Completing the channel to same width and depth at Lower Falls, 2,500 cubic yards, at $5*	12,500 00
5. Excavating a channel to same width and depth at the Upper Falls, 6,500 cubic yards, at $5	32,500 00
Engineering expenses and other contingencies, say	7,987 04
Total	82,487 04
Amount available July 1, 1872	25,487 04
Additional amount required for completing all the improvements as originally contemplated	57,000 00

The increase of the foregoing estimates at the Lower and Upper Falls arises chiefly from the fact that the excavation of the bar at the Lower Falls requires the excavation to be correspondingly increased at the Upper Falls, where there is no tide-water to overcome the effects of the removal of the lower bar.

After opening a cut through the bar at the Lower Falls a new bar with a strong currrent over it was created a short distance above, which will require excavation not estimated for in previous reports, but is included in the estimate submitted above.

V 16.

REMOVING ROCKS AT GLOUCESTER HARBOR, MASSACHUSETTS.

By an act of Congress approved June 10, 1872, there was appropriated for this work the sum of $10,000. This appropriation is to be applied to the removal of the several rocks named as follows, viz:

1. *Babson Ledge.*—This ledge is about 800 feet southwest from Fort Point. It has about 18 feet of water upon it at mean low water; is covered for the greater part with bowlders of various sizes, from small shingle, wedged in between the bowlders, up to pieces of 20 and more tons, some of which have less than 13 feet of water over them at mean low water. Between the 18-foot curves, its extreme length is 260 feet and its greatest width is 178 feet, with an area inside of 3,000 square yards. It is required to obtain a depth of 18 feet of water over this ledge at mean low water, which will necessitate the removal of 670 yards (more or less) of bowlders and ledge.

2. *Clam Rock.*—This rock is situated near the entrance of Harbor Cove; is a round clam-shell-shaped head, cropping out from a solid ledge of coarse, dark-colored granite. Its length is 15 feet and average width 11½ feet; it has 1 foot of water over it at mean low water and rises 8 feet above the bottom surrounding it, and contains about 30 cubic yards above the plane, 9 feet below mean low water, to which depth it is required to be removed.

3. *Pinnacle Rocks.*—These rocks consist of several bowlders, about 500

* A contract has since been made with Mr. Augustus R. Wright, of Geneva, New York, for doing the work at $4.95 per cubic yard.

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feet to the eastward of Clam Rock, the largest of which rises 8 feet 4 inches above its surrounding bottom of soft mud, in which it is imbedded to a depth of from 1 to 1½ feet, and has 8.3 feet of water over it at mean low water. It measures 16 feet in length by an average width of 14 feet, and is 9 feet 8 inches high, containing 54½ cubic yards. The smaller bowlders near it (which form, with the large one, the so-called "Pinnacle Rocks") contain 24 cubic yards (more or less) additional, altogether making 78½ cubic yards (more or less) of bowlders to be removed.

4. *Rock off I. Friend's Wharf.*—This rock is a cropping-out of a granite ledge and is 4 feet above the surrounding bottom. It measures 22 feet in length by 12 feet in width, and has 13 feet of water over its top at mean low water, requiring the removal of 22 cubic yards (more or less) in order to obtain the required depth of 17 feet below mean water.

5. *Rock off Pew's Wharf.*—This is a small granite bowlder containing 3 cubic yards, lying in about 5 feet of water at mean low water.

The contents of the above-named rocks are as follows, viz:

1. Babson's Ledge contains	670	cubic yards, more or less			
2. Clam Rock contains	30	"	"	"	"
3. Pinnacle Rocks contain	76½	"	"	"	"
4. Rock off I. Friend's Wharf contains	22	"	"	"	"
5. Rock off Pew's Wharf contains	3	"	"	"	"
Total	803½	"	"	"	"

*The appropriation for this work will be sufficient to remove the last four rocks entirely, and all the largest bowlders on Babson's Ledge: so that no further appropriation is deemed necessary for this work.

V 17.

IMPROVEMENT OF BOSTON HARBOR, MASSACHUSETTS.

The several works now in progress for the preservation and improvement of this harbor are:

1. The sea-wall for the protection and preservation of Point Allerton;
2. The sea-wall for the preservation and protection of Gallop's Island;
3. The sea-wall for the preservation and protection of Long Island Head;
4. The removal of a part of Kelly's Rock; and
5. Excavating the channel through the Upper Middle Bar to a width of 600 feet and a depth of 23 feet mean low water.

On the 1st of July, 1871, there was available for the several works in this harbor the sum of	$78,644 [illegible]
Amount appropriated by act June 10, 1872	75,000 [illegible]
Total	153,644 [illegible]
Amount expended during the fiscal year ending June 30, 1872	77,933 [illegible]
Amount available July 1, 1872	75,710 [illegible]

*Proposals were invited for this work, and on the 26th of August a contract was made with Mr. George W. Townsend, of Boston, Massachusetts, (the lowest of six bidders) for removing (at $15 per cubic yard) "Clam Rock," "Pinnacle Rocks," "Rock off Friend's Wharf," and "Rock off Pew's Wharf;" also, for removing about 375 cubic yards of bowlders from Babson's Ledge, at $20 per cubic yard.

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1. *Sea-wall on Point Allerton.*—Work upon this wall was commenced in September, 1870, under a contract made May 24, 1870, with Mr. James M. Andrews, and was carried on under that contract until the 1st of June, 1871, when the appropriation of July 11, 1870, under which the contract was made, was exhausted.

The work was then continued under the appropriation of March 3, 1871, with hired labor and machinery, until the 20th August, 1871, and since then, under a contract made the 26th of July, 1871, with Mr. James M. Andrews, the former contractor.

During the fiscal year ending June 30, 1872, the following work has been done: Granite-facing, with concrete foundation and backing laid, an average of 219 linear feet; granite coping laid, 439 linear feet, leaving to be done, in order to complete the wall to its contemplated length of 1,230 feet, an average of 541 linear feet of wall (including concrete foundation, backing, and coping) to be laid; about 5,100 cubic yards of earth to be moved and placed as back-filling and on the slopes of the bluff in rear, and 2,050 superficial yards of paving to be laid behind the wall.

The estimated cost of completion of this sea-wall to contemplated length of 1,230 feet is $61,000.

2. *Sea-wall on Gallop's Island.*—Work upon this wall was commenced in the year 1868, under a contract made May 26, 1868, with Mr. James Andrews, of Biddeford, Maine, and was carried on under that contract until the end of April, 1871, and since then, with hired labor and machinery, up to the latter part of September. The progress made during the fiscal year ending June 30, 1872, is as follows, viz: 1,140 superficial yards of granite paving has been laid; 51 cubic yards of dry-wall built, to connect the eastern end of the sea-wall with the banks in its rear, and about 300 cubic yards back-filling placed, whereby the whole sea-wall has been completed to its contemplated length of 1,745 feet, there remaining only about 5,000 cubic yards of grading to be done on the bluff in its rear.

The estimated cost of the completion of this grading is	$2,500
To which add cost of two stone jettees projected for the protection of the base of this wall	2,000
Total	4,500

3. *Sea-wall on Long Island Head.*—The construction of this wall was commenced in August, 1870, by Mr. James Andrews, under a contract made May 24, 1870, and work was carried on under that contract until the 1st of June, 1871, when the appropriation under which the contract was made became exhausted. The work was then continued under the appropriation of March 3, 1871, with hired labor and machinery, until the 21st of August, and since then under a contract made July 26, 1871, with Mr. James Andrews, the former contractor.

During the fiscal year ending June 30, 1872, the following work has been done upon this sea-wall, viz: Granite-facing, with concrete foundation and backing laid, an average of 522.7 linear feet; granite coping laid, 822.7 linear feet, and about 2,500 cubic yards of the back-filling placed, which leaves to be done, in order to complete the wall to its contemplated length of 2,100 feet, an average of 843½ linear feet of wall (including concrete foundation, backing, and coping) to be laid, about 5,400 cubic yards of back-filling and grading to be done, 3,460 superficial yards of granite paving to be laid, and 50 cubic yards of dry-wall to be built, in order to connect the southeastern end of the

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wall with the bank in its rear. The estimated cost of the completion of this wall to its contemplated length of 2,100 feet is $72,000.

4. *Kelly's Ledge.*—This ledge lies in the main ship-channel directly in the line from the entrance-buoy to Spit light. In 1869 and 1870 this ledge was broken up and removed to a depth of 23 feet at mean low water, with the exception of a few projecting points, which have but 21½ feet of water upon them.

The estimated cost of removal of this ledge to a full depth of 23 feet at mean low water is $500.

5. *Dredging on Upper Middle Bar.*—The contemplated plan for the improvement of this bar consists in the excavation of a channel through it to a width of 600 feet and to a depth of 23 feet at mean low water. From surveys recently made, it appears that the average length of the projected cut is 2,200 feet, and that the depth of the excavation will vary from 1 to 7 feet. This will require the excavation of about 230,000 cubic yards, in addition to that already dredged.

Under a contract made May 24, 1870, with Mr. Emory R. Seward, of Albany, New York, dredging was carried on at this bar until the 1st June, 1871, when the appropriation under which the contract was made became exhausted, 26,120 cubic yards having been removed under the contract, whereby one cut was partially opened to a width of 45 feet and to a depth of from 20 to 23 feet at mean low water; some progress was also made on a second cut. Under instructions from the Department, proposals were again invited for continuing this work by contract under the new appropriation of March 3, 1871, and a contract was made July 29, 1871, with Mr. R. G. Packard, of Brooklyn, New York, (who was the lowest of five bidders,) for doing this work at 57 cents per cubic yard, the work contracted for to be completed on or before the 30th of June, 1872. In the early part of December the contractor commenced operations with his dredging-machine, but finding it impracticable to continue work, on account of the weather, he suspended operations until April, 1872. He then resumed work and continued until the 29th June, 1872, when he completed his contract by the dredging of 20,355 cubic yards in the required time.

The work thus far done upon this bar consists in the excavation of one cut of 40 feet in width and 1,800 feet in length through the whole length of the bar, and a partial completion of a second cut for a length of 1,040 feet.

To complete this channel to the contemplated width of 600 feet will require about 230,000 cubic yards of dredging, which, at 75 cents per cubic yard, would cost $172,500.

The following is a recapitulation of the estimates of the cost of completing all of the unfinished works above named, viz:

1. Sea-wall on Point Allerton	$61,000
2. Sea-wall on Gallop's Island	4,500
3. Sea-wall on Long Island Head	72,000
4. Completing the removal of Kelly's Ledge, say	500
5. Completing the channel through the Upper Middle Bar to a width of 600 feet and 23 feet in depth at mean low water	172,500
Contingencies	30,210
Total	340,710
Amount available July 1, 1872	75,710
Additional appropriations required for completing the above works	265,000
Of this amount there could be profitably expended during the next fiscal year the sum of	$175,000

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For the further prosecution of the above works during the fiscal year ending June 30, 1873, proposals have been invited for extending the sea-walls on Point Allerton and Long Island Head,* and for 35,000 cubic yards of dredging on the Upper Middle Bar. It is also contemplated to remove by hired labor the remaining portion of Kelly's Ledge, and to build two stone piers for the protection of Gallop's Island sea-wall.

The works in Boston Harbor are in the port of Boston, and in the collection-district of Boston and Charlestown, Massachusetts. Those on Point Allerton are near Boston light-house; those on Gallop's Island, near Fort Warren; those on Long Island, near Long Island light-house; and those at the Upper Middle Bar, near Fort Independence.

The amount of revenue collected at the port of Boston for the fiscal year ending June 30, 1872, as furnished by the United States collector, was $23,578,541.68; and he adds: "It would be safe to say that, during the past year, 16,500 vessels have arrived and sailed from Boston Harbor. Their capacity may be estimated as, at least, 2,400,000 tons."

The following papers are hereby appended, viz:

1. Copy of advertisement inviting proposals.
2. Abstract of proposals for each work, with names of bidders.
3. Abstract of contracts, with names of contractors.

No. 1.

Proposals for the improvement of Boston Harbor, Massachusetts.

UNITED STATES ENGINEER OFFICE.
Boston, Massachusetts, June 22, 1871.

Proposals will be received at this office until 3 o'clock p. m. on Saturday, the 22d day of July next, for extending the sea-walls on Long Island and Point Allerton, and for dredging on the "Upper Middle," in Boston Harbor.

The wall on Long Island is to be extended 400 linear feet, more or less, and that on Point Allerton 200 linear feet, more or less, and they both are to be built of granite and concrete, laid in hydraulic cement upon a concrete foundation, in the same manner and of the same dimensions as the walls already finished. The granite must be as good in quality as that heretofore furnished, the cement and other materials of the best quality, the concrete of satisfactory proportions in its component parts, and the workmanship and materials must be in accordance with the drawings, and the whole to the satisfaction of the United States engineer in charge of the work.

Separate bids must be made for each sea-wall, and must be for all the five following items, viz:

1. For wall (granite facing and coping) finished, per running foot.
2. Concrete, for foundation and wall, per cubic yard.
3. Flagging laid, per superficial yard.
4. Excavation for foundation, per cubic yard.
5. Back-filling, per cubic yard.

It is to be understood that each of the above five items includes all the materials and workmanship required for the completion thereof, the use of machinery, teams, carts, and all other expenses whatsoever incident thereto, as well as a general and faithful supervision of the same.

As all the rail-tracks connecting the wharves with the walls, workmen's quarters, wells, sand-pits, stables, &c., the wharf also at Long Island, have been constructed and built by the former contractors at their own expense, the contractors for the sea-walls will be required to purchase such private property or else the right to use the same on such terms as may be determined by three disinterested persons, one of whom shall be the engineer in charge, or such person as he may designate.

*On August 24, 1872, a contract was made with Mr. James M. Andrews for building 225 feet of sea-wall on Point Allerton, and on the 23d of August a contract was made with Mr. James Andrews for building 275 feet of sea-wall on Long Island Head.

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Separate proposals will be received for dredging a channel through the "Upper Middle," so as to obtain a depth of 23 feet at mean low water; 50,000 cubic yards, more or less, of dredging will be required, and the material excavated is to be deposited in such locality as the engineer in charge may direct, the distance not to exceed three miles.

All the work must be commenced not later than the 15th of August next; the sea-walls to be completed on or before the 30th of November next and the dredging on or before the 30th of June, 1872.

Plans and drawings showing the site and character of the works will be open to inspection in this office.

The undersigned reserves the right to reject all bids which, in his opinion, are not favorable to the Government; also, the bid of any person who, in his belief, will not faithfully and promptly perform the contract.

Payments will be made monthly, and 20 per cent. will be reserved therefrom until each work is completed, and be forfeited in the event of the non-fulfillment of the contract in the time and manner required.

Persons desiring to make proposals are requested to call at this office, in No. 2 Bulfinch street, for forms of same, and for more definite information, if desired; and on transmitting their bids (which must be in duplicate) they will indorse thereon "Proposals for Sea-wall at Long Island," or "Point Allerton," or "Dredging the Upper Middle," as the case may be.

GEO. THOM.

Lieutenant-Colonel of Engineers, Brevet Brigadier-General, U. S. A.

No. 2.

Abstract of proposals received for the improvement of Boston Harbor, Massachusetts.

No. for reference.	Names of bidders.	Nature of work.	Price.	Remarks.
1	James M. Andrews, Biddeford, Maine.	For wall, (granite facing and coping finished,) per running foot.	$41 60	Sea-wall on Point Allerton.
		Concrete foundations and wall, per cubic yard.	11 00	
		Flagging laid, per superficial yard	6 49	
		Excavation for foundation, per cubic yard.	1 00	
		Back-filling, per cubic yard	50	
2	James Andrews, Biddeford, Maine.	For wall, (granite facing and coping finished,) per running foot.	32 57	Sea-wall on Long Island Head.
		Concrete for foundation and wall, per cubic yard.	10 25	
		Flagging laid, per superficial yard	6 25	
		Excavation for foundation, per cubic yard.	1 00	
		Back-filling, per cubic yard	1 00	
			C. yard.	
3	Thomas S. Strong, Sandy Hill, N. Y.	Dredging on Upper Middle Bar, 50,000 cubic yards, more or less.	$1 19	As measured in the scows
4	John Monks, New York City.		1 05	
5	N. C. Munson, Boston, Mass.		85	
6	Emory R. Seward, Albany, N. Y.		74	
7	R. G. Packard, Brooklyn, N. Y.		57	

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No. 3.

Abstract of contracts made for the improvement of Boston Harbor, Massachusetts.

No. for reference.	Names of bidders.	Nature of work.	Price.	Remarks.
1	James M. Andrews, Biddeford, Maine.	For wall, (granite facing and coping finished,) per running foot.	$41 60	Sea-wall on Point Allerton.
		Concrete for foundation and wall, per cubic yard.	11 00	
		Flagging laid, per superficial yard	6 40	
		Excavation for foundation, per cubic yard.	1 00	
		Back-filling, per cubic yard	50	
2	James Andrews, Biddeford, Maine.	For wall, (granite facing and coping finished,) per running foot.	32 57	Sea-wall on Long Island Head.
		Concrete for foundation and wall, per cubic yard.	10 25	
		Flagging laid, per superficial yard	6 25	
		Excavation for foundation, per cubic yard.	1 00	
		Back-filling, per cubic yard	1 00	
			C.yard.	
3	R. G. Packard, Brooklyn, N. Y.	Dredging on Upper Middle Bar, 50,000 cubic yards, more or less.	57	As measured in the scow.

V 18.

IMPROVEMENT OF DUXBURY HARBOR, MASSACHUSETTS.

From surveys recently made of this harbor, it appears that the only part which needs improvement is that known as Miles Channel, (or South Channel,) which extends from the "Cow-Yard," so-called, up by the southern point of Captain's Hill. This channel is much contracted in width and made crooked, for a distance of about 1,500 feet, by Splitting-Knife Bar, and the projecting point immediately below, up to which point the channel is 300 feet or more in width, with a depth of not less than 8 feet at mean low water, or 17.3 feet at ordinary high water. It is recommended that this channel be straightened and enlarged at these places, so as to have a width of 250 feet, with a depth of 8 feet at mean low water. This will require about 45,000 cubic yards of dredging, the materials being, for the most part, fine sand and some mud.

An examination recently made of Duxbury Beach shows that the Government work done there several years ago for the preservation of this beach, and consequently of this harbor, sheltered by it, had greatly strengthened and benefited the beach. There are, however, several depressions of from 12 to 15 inches on the beach between High Pine Hill and Plum Hill, which it is advisable to strengthen with brush-work, the cost of which would be about $500.

The estimated cost of the work proposed for the improvement and preservation of this harbor is as follows, viz:

1. Dredging in Miles Channel 45,000 cubic yards, at 40 cents	$18,000
2. Preservation of Duxbury Beach	500
3. Contingencies, say	1,500
Total	20,000
Amount appropriated by act of Congress approved June 10, 1872	$10,000
Additional amount required for its completion	10,000

The amount now available for this harbor is to be applied to the improvement of Miles Channel, the work to be done by contract, for which proposals will be invited.

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V 19.

IMPROVEMENT OF PLYMOUTH HARBOR, MASSACHUSETTS.

The improvement contemplated for this harbor consists in the construction and repairs of a bulkhead and jettees on Long Beach, made for the preservation of the beach, and for its protection from the storms to which it is exposed. This beach serves as a breakwater and affords to the harbor its only protection from the easterly storms.

By act of Congress approved July 11, 1870, there was appropriated for the improvement of this harbor	$10,000 00
And by act of March 3, 1871	10,000 00
And by act of June 10, 1872	2,500 00
Total	22,500 00
Amount available July 1, 1871	$8,906 51
Amount expended during the fiscal year ending June 30, 1872	8,141 85
Amount available June 1, 1872, (including appropriation of June 10, 1872)	3,264 66

On the 26th of May, 1871, I made a contract with Mr. J. A. Blaisdell, of Greenland, New Hampshire, (the lowest of five bidders,) for completing the brush bulk-head and jettees near the extremity of Long Beach, at $3.86 per linear foot; and on the 27th of May I made a contract with Mr. George Clapp, of Boston, Massachusetts, (the lowest of six bidders,) for delivering and piling stone upon the beach, at its outer extremity, so as to connect the beacon with the wooden bulk-head, at $2.25 per ton.

Work was commenced under both of these contracts in the month of June; that on the brush bulk-head and jettees was satisfactorily finished in August, 1871, under which 641½ linear feet were completed: and the contract with Mr. Clapp for the stone bulk-head was completed in the month of September, 1871, under which 2,028 tons were delivered and placed in position.

In addition to the work completed under the contracts, extensive repairs have been made upon the brush bulk-head and jettees along the beach, and beach-grass planted in places where most necessary. These repairs were also finished in the month of September, 1871, when all the contemplated works were completed, with the expectation that nothing further would be required unless rendered necessary by storms from which the beach is at any time liable to injury.

The strength and efficacy of these bulk-heads and jettees were put to a very severe test by the extraordinary gale of November 15, 1871, during which the tide rose about 5½ feet above its ordinary height, and by which some damage was done to a portion of the bulk-head built in 1870, but not so serious as to endanger the security of the harbor.

The appropriation now available for this harbor is to be applied to repairing the bulk-head damaged by the storm of November 15, 1871, as well as all other parts of the bulk-head and jettees which require it; to planting beach-grass for preserving the beach, and to extending the stone bulk-head from the beacon toward the shore.*

* In July and August, 1872, the repairs were in part made, and 613 tons of stone were placed on the extension of the stone bulk-head, whereby the appropriation of June 10, 1872, was nearly exhausted.

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The estimated cost of this work is as follows, viz:

1. Extending stone bulk-head, 1,500 tons granite, at $2.25	$3,375 00
2. Repair of bulk-head and jettees, &c	2,500 00
3. Contingencies, say	389 68
Total	6,264 68
Amount available July 1, 1872, as above	3,264 68
Additional amount required for completing the required improvements	3,000 00

V 20.

REMOVAL OF ROCKS AT THE ENTRANCE OF WELLFLEET HARBOR, MASSACHUSETTS.

By act of Congress, approved June 10, 1872, there was appropriated for this work the sum of $5,000, with which the following rocks are to be removed, viz:

1. *Channel Rock.*—This rock is situated about 2,000 yards to the southeast of Billingsgate light, and lies in about 12½ feet of water at mean low water, having only 2 feet of water over its shallowest part; its greatest dimensions being 20 by 19, by 10½ feet in height. It is a hard gray granite bowlder, and contains 92 cubic yards, more or less.

2. *Lobster Rock.*—This rock is situated in mid-channel, about 1,400 yards to the eastward of Billingsgate light. It is a column-shaped bowlder, lying in 18 feet of water, with 4½ feet of water on it at mean low water; its greatest dimensions being 13¼ by 10¼ feet, by 14 feet in height, and its contents 60 cubic yards, more or less.

3. *Lumpfish Rock.*—This rock is a small bowlder, 500 yards northeast of Lobster Rock. It lies in 9 feet of water, with 3½ feet over it at mean low water; its greatest dimensions being 10 by 6 feet, by 6 feet in height, and its cubic contents 12 yards, more or less.

4. *Mayo's Rock.*—This rock is situated in mid-channel, 40 feet west of "buoy No. 7." It is a bowlder of pyramidal shape, with $2\frac{7}{10}$ feet of water on its shallowest part, and lies in 8 feet of water at mean low water; its greatest dimensions being 13½ by 9 feet, by 5 feet in height; and its contents 20 cubic yards, more or less.

5. *Bay Rock.*—This rock is situated about 700 yards to the northwest of Mayo's Rock. It is a wedge-shaped bowlder, lying in 6 feet of water, and is awash at low tide. Its greatest dimensions are 15 by 8, by 9 feet in height, and its contents 20 cubic yards, more or less.

Proposals will be invited for removing all these rocks by contract.*

No further appropriation is required for this work.

V 21.

IMPROVEMENT OF PROVINCETOWN HARBOR, MASSACHUSETTS.

The work done up to the 1st of July, 1871, for the improvement and preservation of this harbor, was as follows, viz:

1. Bulk-heads and jettees of various descriptions had been built

*Five proposals were received for this work, and a contract was made on the 23d of August with Mr. Samuel Dyer, of Truro, Massachusetts, for the removal of all the rocks for $3,000, to be done on or before the 20th of December next.

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from time to time along Beach Point, for its preservation and protection, both by the United States Government and by the local authorities.

2. A dike was built in 1868 and 1869, by the State of Massachusetts, across the outlet of East Harbor Creek.

3. A dike was built in 1868 and 1869, by the United States Government, across East Harbor Creek, at the "wading place" near High Head, about two miles above the outlet of the creek.

4. Wooden bulk-heads and jettees had been built at different times for the protection and preservation of the beach on Long Point.

5. A stone apron-work had been commenced for the protection and preservation of the outer end of Long Point, opposite the light-house and the "Three-gun Battery."

6. Beach-grass had been planted on Long Point, Cove section, and Oblique section; and at the last two places brush had also been laid for their further protection. A very extensive and accurate resurvey was made in May and June, 1871, which embraced all the points of interest in and near this harbor, and showed, by comparison with the various former surveys, the changes that had since occurred.

The following additional work has been done during the fiscal year ending June 30, 1872:

1. Proposals were invited for building, by contract, a dike of 272 feet in length at Abel Hill, across the head of Lancey's Harbor, in order to prevent the flow of tide and sand through there into the inner harbor of Provincetown. A contract was made October 17, 1871, with Mr. Samuel Dyer, of Truro, Massachusetts, (the lowest of five bidders,) for doing it, for the sum of $5,250. In April, 1872, this dike was finished in a very substantial and satisfactory manner.

2. Repairs were continued upon the bulk-head and jettees, and beach-grass was planted on Beach Point, in places where most necessary: beach-grass has also been planted near the new dike at Abel Hill; and some marsh-grass planted on the flats between Stevens's Point and Lobster Point for arresting the action of the tidal currents upon the sand, and to prevent its being carried into the inner harbor.

3. Three hundred and eight tons of granite grout have been deposited upon Long Point Beach for the protection and preservation of the outer end of the point, opposite the light-house and the "Three-gun Battery."

In May and June, 1872, a resurvey was made of Cove section and Oblique section, and elaborate current observations were made in the inner harbor of Provincetown, with a view to determine "what changes, if any, have taken place there, and especially whether the closing of the mouth of East Harbor has changed the direction of the flood-current in that vicinity, and whether that current was carrying any material from the shoal off East Harbor into the best part of the harbor of Provincetown." Accurate drawings in much detail have been made of the surveys made in May and June, 1871, as well as of the resurvey and current observations made in May and June, 1872, which, with reports thereon, have been forwarded to the Department.

The following work now remains to be done for completing the contemplated improvements of this harbor, viz:

1. Completing the stone bulk-head for the protection of Long Point Beach, requiring about 1,000 tons more of rubble-stone, the estimated cost of which, at $2.40 per ton, is	$2,400 00
2. Work to prevent the extension of the flats between Stevens's Point and Lobster Point, the estimated cost of which is	3,000 00
3. The extension of the jettees near the State dike, (from Nos. 50 to 92)	6,000 00

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4. Continuing the repairs of the bulk-head and jettees on Beach Point	$3,000 00
5. Contingencies, (say)	1,584 43
Total	15,984 43
Amount available July 1, 1872	$5,984 43
Additional amount required for completing all the contemplated improvements, and for repairs	10,000 00

all of which can be profitably expended during the next fiscal year.

Amount available July 1, 1871	$9,029 25
Amount expended during the fiscal year ending June 30, 1872	8,044 82
Amount on hand July 1, 1872	984 43
Appropriated by act of June 10, 1872	5,000 00
Amount available July 1, 1872	5,984 43

This amount is to be applied to the partial completion of the stone bulk-head on Long Point Beach, to the partial extension of the jettees on Beach Point, and to such repairs as may be necessary on the works on Beach Point, the work to be done by hired labor.

The following information is furnished as required by law, viz:

Provincetown is a port of entry, within the collection-district of Barnstable. The amount of revenue received at this port, from all sources, during the fiscal year was $1,990.

The number of vessels engaged in coasting trade and in foreign trade that resort to this harbor for refuge yearly is, (as stated by the deputy collector at that port,) according to the best data at hand, not less than 2,000 sail; not less than 150 enter the harbor during the year, and from 4,000 to 6,000 entries of fishing-vessels made here during the year. At certain parts of the season 500 sail may be seen at anchor at the same time. There are 250 sail of vessels belonging to this port, including fishing-craft, that bring in upward of 100,000 quintals of fish and from 20,000 to 30,000 barrels of mackerel, and 20 sail of whalers, that, in prosperous seasons, bring $200,000 to $300,000 worth of oil home.

The papers described as follows are hereto appended, viz:

1. Copy of advertisement inviting proposals.
2. Abstract of proposals received.
3. Abstract of contracts made.

No. 1.

UNITED STATES ENGINEER OFFICE, BOSTON, MASS.,
September 9, 1871.

Proposals will be received at this office until 3 o'clock p. m. on Tuesday, the 10th day of October, 1871, for building a dike at the head of Lancey's Harbor, near Abel Hill, in Provincetown, Massachusetts, the work to be completed on or before the 31st of December next.

For plans and specifications of the work to be done please apply at this office.

The undersigned reserves the right to reject all bids which, in his opinion, are not reasonable; also, the bid of any person who will not, in his belief, faithfully and promptly perform the contract.

Payment will be made on the completion of the work.

Persons desiring to make proposals are requested to call on the undersigned at his office, at No. 2 Bulfinch street, for forms of same, and for more definite information, if desired; and on transmitting their bids (which must be in duplicate) they will please indorse thereon "Proposals for building a dike."

GEORGE THOM,
Lieutenant-Colonel of Engineers.

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No. 2.

Abstract of proposals for improvement of Provincetown Harbor, Massachusetts.

No. for reference	Nature of work.	Name of bidders.	Price.	Remarks.
1	Building a dike at the head of Lancey's harbor, near Abel Hill.	George W. Lawrence, Damariscotta, Maine.	$7,890	Length of dike [illegible] feet, and 17 [illegible] wide on top.
2	.....	George Clapp, Boston, Massachusetts.	7,434	
3	.....	Joshua E. Bowley and Gideon Bowley, Provincetown, Massachusetts.	6,150	
4	.....	Isaiah Gifford, Provincetown, Massachusetts.	5,700	If 10 feet [illegible] $5,000.
5	.....	Samuel Dyer, Truro, Massachusetts.	5,250	

No. 3.

Abstract of contracts made for improvement of Provincetown Harbor, Massachusetts.

No. for reference.	Nature of work.	Name of contractors.	Price.	Remarks.
1	Building a dike at the head of Lancey's Harbor, near Abel Hill.	Samuel Dyer, of Truro, Massachusetts.	$5,250	Length of dike [illegible] feet, and 17 [illegible] wide on top.

V 22.

IMPROVEMENT OF HYANNIS HARBOR, MASSACHUSETTS.

This harbor derives its importance chiefly from the shelter which it affords to the coasting-trade against violent storms from every quarter. By the breakwater alone it is protected from southerly and southwesterly storms. This work is about 1,170 feet in length, and its general course about east-southeast. It was built several years since of blocks of stone, thrown in at random, to about the height of high water. These stones have become more or less displaced by the violent storms to which they have been exposed, and the height of the work has thereby so much decreased that of late it has not afforded all the benefit for which it was intended. In order to give it the required height and stability it has been in part reconstructed in the following manner, viz: The random stone has been rebuilt from low water, where the work has a thickness of 20 feet, up to about 4 feet above high water, where it has a thickness of 16 to 18 feet. Upon this foundation are placed two courses of top wall, having a rise of 3 feet and a width of 10 feet, doweled with composition metal bolts. On the 1st of January, 1870, 625 linear feet of this work had been rebuilt; and for continuing the rebuilding of the work the following appropriations have been since made by Congress, viz:

By act of July 11, 1870	$12,000
And by act of March 3, 1871	10,000
Total	22,000
Amount available July 1, 1871	$9,905
Amount expended during fiscal year ended June 30, 1872	9,905
Balance on hand July 1, 1872	0,000

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Under the contract made June 9, 1871, with Mr. George Clapp, of Boston, Massachusetts, he had on the 30th of June, 1871, (as heretofore reported,) built up 175 running feet of the foundation, ready for the top wall; and in the month of September following he had rebuilt and finished 250 running feet of the work in completion of his contract, leaving 225 linear feet of the work to be rebuilt. The following is an estimate of the cost of the completion of the work, viz:

Rebuilding 225 linear feet of wall, at $40	$9,000 00
Adding for contingencies	1,000 00
Total amount required for its completion	10,000 00

This amount could be profitably expended upon the work during the next fiscal year. Indeed it is highly important that the work should be completed at once, not only on account of its great benefit to commerce, but also on account of its liability to injury from the violent storms to which it is exposed in its unfinished condition.

This work is situated in the Barnstable collection district, Hyannis being the port of entry, where is located the Hyannis Harbor light-house. The amount of revenue collected at Hyannis during the fiscal year is stated to be about $1,100, being much reduced on account of the tonnage dues being taken off.

Seven thousand nine hundred and twelve vessels are stated to have passed the harbor and breakwater during the past year, of which, it is believed, that not less than one-half of that number went inside of the harbor and breakwater, it being not unusual to see from sixty to eighty sail of vessels in the harbor at one time in the fall of the year wind-bound.

V 23.

IMPROVEMENT OF WAREHAM HARBOR, MASSACHUSETTS.

A survey of this harbor was made in October, 1871, under my direction, "with a view to dredging the same and fitting it for a harbor of refuge," the report on which, with the explanatory drawings, were transmitted to the Department on the 7th of December last, with the recommendation—

1. That a channel be excavated for a distance of 1,300 feet across Quahaugh Bar, to a width of 250 feet, and to a depth of 9 feet at mean low water, giving thereby $13\frac{2}{10}$ feet at ordinary high water; the channel to be located as indicated on Plan I.

2. That the present channel immediately below the Franconia Iron-works be widened as indicated on Plan I, and also deepened to a depth of 9 feet at mean low water, by which improvement vessels could, with ease and safety, ascend to the wharves at Wareham, with that depth.

3. The removal of a sunken ledge and bowlder from the channel of Weweanlit River, which, uniting with Wareham River, forms an extension of the harbor of Wareham.

The estimated cost of these improvements was as follows, viz:

1. Dredging channel across Quahaugh Bar, 41,260 cubic yards, at 45 cents	$18,567
2. Widening and deepening channel below Franconia Iron-works, 45,300 cubic yards, at 45 cents	20,385
3. Removing ledge and bowlder in Weweanlit River, 150 cubic yards, at $20	3,000
Contingencies, say	3,048
Total	45,000

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Amount appropriated by act of June 10, 1872	$10,000
Additional amount required for completing the contemplated improvements	35,000

Of which $15,000 could be profitably expended during the next fiscal year.

By instructions from the Department, dated June 14, 1872, the charge of this work was transferred to Major G. K. Warren, Corps of Engineers, on the 30th of June, 1872.

V 24.

IMPROVEMENT OF TAUNTON RIVER, MASSACHUSETTS.

The improvement contemplated for this river consists in the excavation of a channel to a width of 60 feet, and a depth of 4½ feet at mean low water, giving 9 feet at mean high water through the several shoals which obstruct its navigation between Dighton and Weir Village, in the city of Taunton, a distance of six miles.

By act of Congress, approved July 11, 1870, there was appropriated for this work the sum of	$10,000
And by act of March 3, 1871	10,000
Total	20,000
Of which there was available July 1, 1871	$19,387
Amount expended during the fiscal year ending June 30, 1872	13,387
Leaving available on the 1st July, 1872	6,000

These appropriations have been applied to improving the river at the shoal known as "The Needles," formerly the most dangerous and difficult part of the river to navigate. Here the channel was completed on the 22d of November, 1871, to the contemplated width and depth, under the contract made March 29, 1871, with Mr. Emory R. Seward, of Albany, New York, the terms of which were reported in my last annual report.

The estimates heretofore made for improving this river have been based upon the survey of the river made in 1852. But a resurvey of the river at and above "The Needles," commenced under my direction in November last, (which was suspended before completion, on account of the ice,) shows that these estimates will have to be materially increased. For instance, shoal No. 3, (as numbered from Wier Village downward,) is found on the resurvey to require the excavation of 8,000 cubic yards, (instead of 3,600 cubic yards, as previously estimated,) the cost of which, estimated at $1 per cubic yard, is $8,000.

A shoal has also been found between shoal No. 3 and "The Needles," called "Burt's Rock Shoal," requiring about 700 cubic yards of excavation, not before estimated for; the cost of which is now estimated at $700.

An incomplete survey of shoal No. 2 shows that probably not less than 15,000 cubic yards of excavation will be required at that place: and from a partial examination of "shoal No. 1," it is believed that the estimate will have to be correspondingly increased for that locality.

Before submitting a corrected estimate for the improvements in the river, it will be necessary to complete the unfinished resurvey referred

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to. By act of Congress, approved June 10, 1872, an additional appropriation of $10,000 has been made for the improvement of this river, which it is respectfully recommended shall be applied—

1. To the completion of the survey of shoals No. 1 and 2, the estimated cost of which is	$300
2. To excavating channel through Burt's Rock Shoal, (as above)	700
3. Excavating channel through shoal No. 3	8,000
Adding for contingencies	1,000
Total	10,000

The above work it is believed can be completed before the close of the present season without difficulty.

In order to complete the contemplated improvement of this river, up to the head of its navigation at Wier Village, there will be required an additional appropriation of not less than $30,000, of which $20,000 could be profitably expended upon the work during the fiscal year ending June 30, 1874.

Accompanying this are drawings showing shoal No. 4 (The Needles) before and after dredging; also, shoal No. 3, and Burt's Rock Shoal, as resurveyed under my direction in November, 1871.

V 25.

IMPROVEMENT OF EDGARTON HARBOR, MASSACHUSETTS.

A survey of this harbor was made under my direction in the latter part of April last, in compliance with a resolution of the House of Representatives of April 7, 1872, "with a view to dredging and improving the same so as to afford greater protection and facilities to commerce," the report on which, with the explanatory drawings, were transmitted to the Department on the 10th of May, 1872.

This survey showed that the southern channel through Cotamy Beach had, about two years before, been closed during a violent gale, whereby the flow of the tidal currents had been stopped much to the injury of the harbor, and the local community was deprived of a direct communication with valuable fishing-grounds to the southward, as well as of the opportunity of furnishing pilotage to strange vessels on the ocean coast. With a view, therefore, to restoring the former regimen of the currents or of recovering the advantages of a direct communication to the southward with the ocean, it was recommended by me that a channel should be at once opened through Cotamy Beach, in the shortest and most direct course to the ocean, to a width of 150 feet, and a depth of 4 feet at mean low water.

The estimated cost of this channel is:

1. 34,000 cubic yards excavation, by dredging, at 50 cents	$17,000
2. 10,000 cubic yards, with carts and barrows, at 30 cents	3,000
Adding for contingencies, say	2,000
Total	22,000
Amount appropriated by act of Congress, approved June 10, 1872	$20,000

No further appropriation is recommended to be made for this harbor. By instructions from the Department, dated June 14, 1872, I transferred the charge of this work to Major G. K. Warren, Corps of Engineers, on the 30th June last.

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V 26.

SURVEY OF WELL'S HARBOR, MAINE.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, November 2, 1871.

This harbor is formed by a small estuary known as Webhannet River, which is about one and a half miles in length and, on an average, about 200 yards in width, having two small branches, each about half a mile in length. It is situated about midway between Portland, Maine, and Portsmouth, New Hampshire, and seven miles to the westward of Goat Island light, off Cape Porpoise. A wide, sandy beach extends along the coast for several miles above and below this harbor, causing, at its entrance, a bar about 500 yards in width, with 2½ feet of water upon it at mean low water, or 12 feet at high water, while immediately inside this bar there are, in a space of but small extent, from 6 to 8 feet of water at mean low water.

The harbor is, for the most part, surrounded by low, marshy ground, except near its head, where it is nearly dry at low water, and has but 10 feet of water at high water, the two smaller branches having but 7 to 8 feet at high water. From which facts it is seen that, although vessels may, at high water, cross the bar with 10 to 12 feet of water, they cannot reach the wharves at the head of the harbor with more than 7 to 9 feet of water.

The survey of this harbor was provided for by the river and harbor bill of March 3, 1871, and for this reason it is supposed to have been called for with a view to the improvement of its navigation. Several years since a crib-work, ballasted with stone, was built by the United States Government at the entrance to the harbor on the northern shore, apparently for the purpose of contracting its width and increasing its depth over the bar. This crib-work, though somewhat injured by the action of the tides, is still in a tolerably good condition, and with some repairs would answer sufficiently well, for the present, the purpose for which it was intended. Its length is about 250 yards, which is believed to be sufficient, as the effect of increasing it would only be to throw the bar farther outward, as has apparently already been done, if indeed the crib-work could withstand the violence of the storms to which, on its extension, it would be in a much greater degree exposed.

Again, it might be suggested to deepen the harbor by dredging so as to allow larger vessels to reach the wharves at its head; but the constantly shifting character of its sandy bottom would render this impracticable and a fruitless waste of money.

This harbor is situated in the Kennebunk collection-district; its commerce is very small and unimportant, there being but twelve small vessels owned in the place. During the fiscal year ending June 30, 1871, no revenue whatever was collected there.

In view of all these facts it would not, in my opinion, be advisable at the present time to give any attention to the improvement of this harbor further than the repair of the crib-work and the placing of the buoy at its outer end, the cost of which would be about $5,000.

Accompanying this is a map of Webhannet River, showing the position of the bar and of the crib-work at its mouth, as well as the depth of water at mean low water.

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V 27.

SURVEY OF FIFTEEN-MILE FALLS, NEW HAMPSHIRE.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, November 1, 1871,

A survey was made of this place during the months of December, 1870, and January, 1871, which survey embraced the falls for an extent of twenty-one and one-half miles, the falls and mill-dam at Northumberland, New Hampshire, (opposite Guildhall, Vermont,) the bridge and rapids in Monroe, New Hampshire, (opposite Barnet, Vermont,) McIndoe's Falls and mill-dam and the ledge about one mile above, and Dodge's Falls and mill-dam. Maps and drawings of all these localities were forwarded to the Department, as a part of my report thereon, dated February 11, 1871.

This survey was made upon the ice, which offered advantages not to be had under any other circumstances, and it is believed to be sufficiently accurate and reliable for the purposes for which it was intended. I have been unable to ascertain the object of the *resurvey* called for by act of March 3, 1871, unless it was for the purpose of again bringing the matter up for consideration. An additional survey, however, has been made of the river for an extent of about two miles below the foot of the "falls," so as to embrace the mouth of Passumpsic River and the islands in its vicinity, a map of which is herewith inclosed.

Fifteen-Mile Falls form a part of Connecticut River, commencing at Dalton, New Hampshire, about two hundred and seventy-five miles above the mouth of the river, and extending down to Monroe, New Hampshire, a distance of twenty-one and one-half miles.

An investigation of the matter shows that the object of the contemplated improvement of this locality is solely to facilitate the lumber trade of the country adjacent to the river and its tributaries above the falls, but that there are diverse opinions as to the manner and desirableness of improving it among the leading business men of the country, men who have had the most experience in its lumber trade and who are most interested in it. It appears that the river is used for the transportation of lumber only during the higher stages of the water, or when not below its medium height; there being in the Fifteen-Mile Falls about three feet of water in its lowest stages, and about twelve to fourteen feet in its ordinary spring freshets. The obstructions to its transportation are confined to but few points between the mouth of Wells River and Connecticut Lake, near the source of Connecticut River. Wells River is fourteen miles below the foot of Fifteen-Mile Falls, and about one hundred miles, by river, below the foot of Connecticut Lake. Formerly, before railroads were in operation along and near this river, improvements were made by private corporations at the most difficult points, by removing some of the most troublesome bowlders in Fifteen-Mile Falls, and building "slips" or sluice-ways over the mill-dams at McIndoe's Falls and Dodge's Falls—both situated between Fifteen-Mile Falls and Wells River. Below Wells River rafts were run down the Connecticut to Springfield, Massachusetts, and Hartford, Connecticut, through locks which had been built by private corporations at the following points, viz: the White River locks at Hanover, New Hampshire; Queechy locks, at Hartford, Vermont; Bellows Falls locks, at Bellows Falls, Vermont; Miller's River locks and Turner's Falls locks, at Montague, Massachusetts; Hadley Falls locks, at Hadley Falls, Massachusetts; and some below Springfield, which were used in

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low stages of the river. These locks were built originally for slack-water navigation of the river by boats sixty feet in length and thirtene feet in width; and it was the size of these locks which regulated the dimensions of the rafts sent from up river. These locks were built of wood, and in course of time required much repair, but instead of repairing them, their use was abandoned when the railroads along the river and its tributaries furnished facilities for the transportation of sawed lumber to the most desirable market. So that, of late years, the *sawed* lumber has been transported altogether by rail, that from Northumberland, New Hampshire, and above, to Portland, Maine, and that from below Northumberland to Boston, Springfield, and other points reached by railroad.

It is the opinion of some that the only improvement to be derived is the removal of such obstructions only as will facilitate the running of logs, and that, whatever facilities may be provided for rafting sawed lumber, it is not probable that it would be transported otherwise than by railroad; while others express the opinion that the lumber trade of the river would be greatly benefited, not only by removing obstructions to the running of logs, but also by making the proposed improvements for the rafting of sawed lumber, whereby the lumber trade would be much increased, owing to a diminished cost of transportation, as compared with the present railroad prices, and a saving in freight realized of not less, probably, than from fifty to seventy-five thousand dollars a year; this estimate being based on the fact that there would be a saving of not less than $2 per thousand feet of lumber on the present railroad prices, and on the fact that the quantity of lumber now cut on the river and its tributaries above Fifteen-Mile Falls is about fifty millions of feet, and would probably be increased to seventy-five millions a year, of which one-half would probably be transported in rafts to markets on the river below. This increase would necessarily depend also upon the repair and re-opening, for rafting business, of the several locks below Wells River; whereas the running of logs would be independent of those locks. The lumber trade would doubtless be much increased by either method of improvement, and separate estimates are herein submitted for the cost of each, applied only to localities above Wells River.

The following are the principal difficulties, and the points where they occur, named in the order of their locality, viz:

1. *The mill-dam at Northumberland, New Hampshire, opposite Guildhall, Vermont.*—This place is about fourteen miles above the head of Fifteen-Mile Falls. The river here, about 300 feet wide, is obstructed by a crib-work dam, which extends up the river in zigzag lines nearly to the bridge, the dam being 2 feet high at its upper extremity and 6 feet at its lower extremity, as represented on the drawing heretofore forwarded. This dam is so arranged in order to prevent the overflow of lands on low banks above. As built, it offers no obstruction to the running of logs when the river is at a suitable height for that business; but for the rafting of sawed timber it would be desirable to have a slip or sluice-way near the saw-mill at the western extremity of the dam. A sluice-way, constructed of timber, on the plan described in the drawings heretofore forwarded, would, it is believed, meet the object in view. In order to prevent any unnecessary waste of water at this dam, it is proposed to have a gate constructed, or else to have planks let into grooves at the head of the sluice-way, the planks being removable at pleasure.

2. *Fifteen-Mile Falls.*—The river at these falls averages about 250 fe

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in width, and is obstructed with numerous bowlders, especially at the head of the falls near "Sumner's," and in the "Three-Mile Rapids," or "Horse-race," near the foot. These bowlders vary in size from 2 to 10 feet in diameter, but it is only the largest of these, varying from 5 to 10 feet in diameter, that it is particularly desirable to have removed. In order to open a channel of the desired width, say 150 feet, it would require the removal of from 300 to 400 of these bowlders. This improvement is required as well for the running of logs as for the rafting of sawed lumber. Below the "Falls" the river widens out, and contains numerous islands and channels, for a distance of about two miles, or for a distance of about half a mile below the mouth of Passumpsic River. In the running of logs difficulties are here met with from their liability to leave the main channel and lodge upon the islands and flats, where they have to remain for a rise of the river, or else would require much labor to be removed into the proper channel. It is believed that these difficulties would be obviated, in a great measure, by *booms* placed each side of the channel, (marked A, B, C, D, E, F, and G, in the accompanying drawing,) so as to divert all the logs into that channel. This, however, would involve the necessity of the removal of the booms during the winter-months, to avoid destruction by the ice.

3. *Rapids at the bridge in Monroe, New Hampshire, opposite Barnet, Vermont.*—These rapids are about four miles below the foot of Fifteen-Mile Falls, or ten miles above Wells River Junction. At this place there is a narrow channel, which follows the south or left shore of the river, as shown in the drawings heretofore forwarded, through which rafts were formerly run. The fall here is but ten inches, and there do not appear to be any difficulties requiring attention.

4. *Ledge about one mile above McIndoe's Falls, or five miles below the foot of Fifteen-Mile Falls.*—This ledge is about in the middle of the river, and is so situated as to force rafts down its eastern channel upon a rocky point in the bend below. With a view to facilitating the rafting of lumber, it is desirable that the ledge should be removed, so that rafts may be run clear of the rocky point below. The extent of this ledge, which it is proposed to remove, is 96 feet in length by 17 feet in width, and about 1 yard in depth, equal to about 180 cubic yards.

5. *McIndoe's Falls and mill-dam, eight miles above Wells River Junction.*—Here the river widens to a distance of about 500 feet at the dam. This dam is of wooden crib-work, and is in good condition. It rests on a slate ledge, the strata of which are nearly vertical and at right angles nearly to the river. The fall of water is 14.8 feet, and affords water-power for the most extensive saw-mills on the river. About midway of the dam there is a ledge, through which a sluice-way was once cut, some of the wood-work of which still remains. This sluice-way is about 100 feet in length by 25 feet in width. Logs are now run over this dam without difficulty, but for facilitating the rafting of sawed lumber it is desirable to have the old sluice-way excavated to a sufficient depth, and a new one constructed on the plan previously forwarded. The dimensions of these sluice-ways are regulated, in all cases, by the size of the locks on the lower part of the Connecticut River, heretofore referred to, and by the fact that about 18 inches of water is required to float the rafts. The quantity of rock excavation that would be required for building this sluice-way is 230 cubic yards.

6. *Dodge's Falls and mill-dam, four miles above Wells River Junction.*—These falls are about 350 feet wide at the mill-dam, with a fall of 13.1 feet. The dam is built of crib-work ballasted with stone, and, in its present condition, it offers no obstruction to the running of logs over

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it. For the rafting of sawed lumber, a slip or sluice-way was built several years ago, near the eastern end of the dam, but it no longer exists. The improvement now desired at this place, for facilitating the rafting of sawed lumber, is a slip or sluice-way at the site of the old sluice-way, the plan and dimensions of the sluice-way to be the same as that designated for McIndoe's Falls.

The following estimates are submitted for the improvements proposed as above, viz:

1. *For improving the river for the running of logs only.*

1. Removing bowlders in Fifteen-Mile Falls, (say)	$10,000
2. Booms near foot of Fifteen-Mile Falls	3,000
3. Removing ledge, five miles below Fifteen-Mile Falls	500
4. Engineering and contingencies	1,500
Total	15,000

2. *For improving the river for rafting sawed lumber.*

1. Sluice-way (60 feet long) at Northumberland Falls	$1,000
2. Removing bowlders in Fifteen-Mile Falls, (as above)	10,000
3. Booms near foot of Fifteen-Mile Falls, (as above)	3,000
4. Removing ledge, five miles below Fifteen-Mile Falls, (as above)	500
5. Sluice-way (110 feet long) at McIndoe's Falls, including 230 cubic yards of rock excavation	2,000
6. Sluice-way (110 feet long) at Dodge's Falls, including substructure of crib-work	3,000
7. Engineering and contingencies	2,500
Total	22,000

From the foregoing estimates, it appears that, for the improvement of Connecticut River at Fifteen-Mile Falls and the other localities in their vicinity above Wells River Junction, there will be required the following sums, viz:

1. For its improvement, for the running of logs only	$15,000
2. For its improvement, both for running of rafts of sawed lumber and the running of logs	$22,000

This second estimate does not include the cost of any of the improvements below Wells River, which are indispensable for carrying out the proposed system of improvements. Moreover, the subject of the maintenance of these works is also to be considered, as well as the right of the United States Government to interfere in any manner with the mill dams belonging to private parties, as well as the control and ownership of the proposed improvements when completed—objections, however, which do not so much apply to the proposed improvements for the running of logs only, owing to the character and locality of such improvements.

In consideration of the above facts, it is respectfully recommended that whatever attention the United States Government may see fit to bestow toward the improvement of this river at Fifteen-Mile Falls and its vicinity, for the purpose of facilitating the lumber trade upon it, it should, for the present, be applied solely with a view to the running of logs.

The amount estimated for this is (as above) $15,000, which, it is believed, could be profitably expended upon the work during the next fiscal year.

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V 28.

MERRIMAC RIVER, MASSACHUSETTS.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, February 3, 1872.

GENERAL: I have the honor to submit the following report on the survey of Merrimac River, from the foot of Hazeltine Rapids up to Lawrence, Massachusetts, (a distance of seven and a quarter miles,) made under my instructions by my assistant engineer, Mr. Gorham P. Low, jr., civil engineer, in the months of October and November last.

Accompanying this is the report of Mr. Low, with five drawings, exhibiting the results of the survey. Sheets Nos. 4 and 5 are maps of the Lower Rapids, as surveyed last autumn by Mr. A. C. Both, civil engineer, while inspector of the work, showing the present location of the channel and the progress thus far made in its excavation at that place. These drawings, together with Mr. Low's report, exhibit all the obstacles to the navigation of the river from Haverhill up to Lawrence; they also show that the quantity of work that is necessary for improving its navigation greatly exceeds the estimates heretofore made therefor; and, moreover, that although it is practicable to make the river navigable, in the manner hitherto projected, with a depth of 4 feet of water at low water up through Hazeltine Rapids and the Lower Falls, the head of tide-water, it would be impracticable thus to make it navigable through the Upper Falls and above (without a vast amount of excavation) except in the most favorable condition of the river, which, as stated by Mr. Low, must be as follows, viz: "low water in the river above, caused by shutting off the supply at Lawrence; and a high tide, when the surface of the river at the foot of the Upper Falls would stand at 8 feet above datum-plane."

This stage of the river would be necessary in order to slacken the current at the Upper Falls to a state practicable for navigation, which would seldom occur except at night or on Sundays.

The following is an estimate of the quantity of work to be done and the probable cost of same for thus improving the navigation of this river, viz:

1. Excavating a channel 60 feet wide and 4 feet deep at mean low water through Hazelton Rapids, 1,900 cubic yards, at $6 per cubic yard	$11,400 00
2. Completing the channel to same width and depth at the Lower Falls, 2,500 cubic yards, at $6 per cubic yard	15,000 00
3. Excavating channel No. 2 at the Upper Falls 60 feet wide and 4 feet deep, (as shown on accompanying drawing No. 3,) and removing rocks from channel below, 6,500 cubic yards, at $6 per cubic yard	39,000 00
4. Excavating channel through shoals Nos. 4 and 6, (above Upper Falls,) 4,000 cubic yards, at $3	12,000 00
5. Engineering expenses and other contingencies, say	7,600 00
Estimated cost of obtaining a navigable depth of 4 feet up to the lower lock at Lawrence in an ordinary stage of the river, (being in addition to the amount already expended thereon)	85,000 00

Even with this work it is believed that there would still be great difficulty in passing the Upper Falls, where the velocity of the current is three miles an hour in a medium stage of the river; while a channel excavated to a width sufficient to materially reduce this velocity would so lower the river above as to require the removal of several bars not above estimated for.

The only practicable method of making this river navigable up to

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Lawrence, in all stages of the river, (except freshets,) is, in my opinion, to build a *dam* and *lock* at the Lower Falls, where the ledge, which extends entirely across the river, furnishes an excellent foundation. This dam would have to be about 900 feet in length, and about 9 feet in height, the cost of which, with the lock, together with the dredging that would be required at Hazeltine Rapids, the Lower Falls, the Upper Falls, and above, would probably be not less than $130,000, in addition to the work already done. This would give a channel that would be navigable in all stages of the river, except freshets, and would obviate all the rapid and dangerous currents at the Lower Falls and above.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, December 19, 1871.

GENERAL: I have the honor to report that, in accordance with your instructions of October 1, I have made a general examination of the Merrimac River, Massachusetts, between the foot of Hazeltine Rapids, near Haverhill, and the Lower Locks at Lawrence, together with detailed surveys of such bars and shoals as offer obstructions to navigation. The drawings herewith submitted as the result of this examination are designated as follows:

Sheet No. 1.—Profile of channel of Merrimac River between the foot of the Hazeltine Rapids and the Lower Locks, Lawrence, with maps of bars existing above the Upper Falls.

Sheet No. 2.—Map of Hazeltine Rapids.

Sheet No. 3.—Map of Upper Falls.

The datum-plane assumed for all elevation relating to this work is 10 feet below bench on Ring Rock, at foot of Hazeltine Rapids. From this bench a line of levels was run to the Lower Rocks at Lawrence, a distance of 37,900 feet, measured along the bank of the river, and the zero of all gauges made to correspond with this datum.

The proposed improvement of this river for the purpose of navigation contemplates the clearing of a channel 60 feet wide, and having 4 feet depth of water at low stage. The elevation of the surface of the water at mean low tides and at low stages of the river is found to be at Ring Rock 3.3 feet above the datum-plane, and an estimate has been made for the excavation of a channel-way at the Hazeltine Rapids, 4 feet deep at that height of water. The bottom of the channel estimated for at the Lower Falls is on the same level. At the Upper Falls the bottom of the proposed channel has been placed at an elevation of 4 feet above datum, for reasons to be hereafter submitted.

The excavation of these channels is estimated at the following quantities and cost:

At Hazeltine Rapids:	
1,900 cubic yards of gravel and bowlders, at $6	$11.4[illegible]
At Lower Falls, (estimate of Mr. A. C. Both,) in addition to that already removed, 2,500 cubic yards, at $6	15.[illegible]
At Upper Falls, (channel No. 1,) 11,000 cubic yards, at $6	66.[illegible]
At Shoals No. 4 and No. 6, 4,000 cubic yards, at $3	12.[illegible]
	104.4[illegible]
Contingencies, say	10.6[illegible]
Estimated total cost of obtaining a navigable depth of 4 feet to the Lower Locks, Lawrence, at ordinary stage of the river	115.[illegible]

By reference to the profile of the river shown on sheet No. 1 it will be observed that the fall between the head of the Upper Falls and the foot of the Hazeltine Rapids, a distance of 10,517 feet, is at ordinary high water 3.75 feet. At low tide this is increased to about 7 feet. Two feet of this fall, both at high and low water, is in a distance of 2,000 feet at the Upper Falls, and upon the completion of the channel through the bar at the Lower Falls this slope will be considerably increased, especially at low tide. The present average velocity is about 5 feet per second. During seasons of scarcity, the water-power companies owning the dams and canals above so regulate the discharge that no water is wasted over the dam at Lawrence, but the whole passes through the mill-wheels during the hours of 6½ a. m. and 6½ p. m. The amount of water so flowing on October 10, the river being then low, was according to Hiram F. Mills, esq., chief engineer of Essex County, very nearly [illegible] cubic feet per second during the running of the mills. This amount the proposed im-

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nel will be too small to discharge, and the pool between the head of the Upper Falls and Lawrence will not probably be drawn down more than a foot below its present height during the running of the mills, but during the night it is thought that this height will be so much reduced as to cause only a moderate velocity of water in the channel at the Upper Falls when the tide is high. It is presumed that barges can only be towed over those falls under the circumstances mentioned, viz: low water in the river above, caused by the shutting off of the supply at Lawrence, and a high tide when the surface of the river at the foot of the Upper Falls would stand at 8 feet above datum. The bottom of the channel proposed for these falls has therefore been placed 4 feet below the above surface, or 4 feet above the datum-plane. At present the effect of the tide is not observable above the foot of the falls under consideration.

In the examination of the river above, the following bars having been found and surveyed, are shown on sheet No. 1: No. 4, just below "Gage's Ferry," 17,000 feet above Ring Rock; No. 5, below Fish House, 22,500 feet above Ring Rock; and No. 6, near mouth of Shawshin River, 35,000 feet above the same point. The amount of dredging required upon these bars will depend upon the effect of the excavation below in drawing down the river, but it has been estimated at 2,000 cubic yards each for shoals No. 4 and No. 6, and nothing for No. 5.

I would respectfully call your attention to the fact that the elevation of the miter-sill of the lower lock of the Lawrence Canal is 10.75 feet above datum, while the height of water in the river at that point is only 13.3 feet at ordinary low water, and at extreme low water, after the supply has been shut off over Sunday, the height is only 11.1 above datum.

The depth of water at this miter-sill will be diminished by the clearing of the river below, and should it be the design to navigate the river above Lawrence, it would be necessary to change the level of this lock. It would also be necessary to raise the railroad-bridge crossing near the head of the Lawrence Canal and several road-bridges.

I would also call your attention to the existence of a fall of 10 feet near Lowell, known as "Hunt's Falls." Should it be the intention to improve the river for navigation as far as Lowell, it would be advisable to make an examination at that point.

As before stated, the fall between the head of the upper falls and Ring Rock is 3.75 feet at high tide. The distance being 10,517 feet, and the natural slope of the river for that distance being 1 foot, there remains only 2.75 feet at high tide as available fall for manufacturing purposes should it be deemed advisable to build a lock and dam. This being increased to 6 feet at low tide, the average would be about 4.4.

The surveys seem to show that the water in a channel of 60 feet wide and 4 feet deep would have such a velocity as to make navigation exceedingly difficult, while a channel great enough to materially reduce the velocity would so lower the river above as to require the removal of several bars shown in profile on sheet No. 1.

Very respectfully, your obedient servant,

GORHAM P. LOW, JR.,
Assistant Engineer.

Brevet Brigadier-General GEO. THOM,
Lieutenant-Colonel of Engineers.

V 29.

DUXBURY HARBOR, MASSACHUSETTS.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, December 1, 1871.

By a resolution of the House of Representatives, dated March 9, 1871, an examination or survey of the harbor of Duxbury, Massachusetts, was called for, "with a view to dredging and improving the same so as to afford greater protection and facilities to commerce," together with a "report upon the feasibility of making such improvement, and the probable cost thereof."

This survey has been made under my instructions by Mr. Sophus Haagensen, assistant civil engineer, and his report thereon, dated December 14, 1871, together with the map therein referred to, also prepared under my instructions, are herewith submitted, with my approval of the same.

The accompanying map shows that the main channel from Duxbury

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Pier up to a point opposite the south part of Clark's Island, (which part of the bay forms the so-called "Cow-yard,") is very deep, being at places 44 feet in depth at mean low water; that near the foot of Clark's Island this channel branches into two navigable channels, the westernmost of which leads up to within 3,500 feet from the wharf on Duxbury Point, with an average width of 400 feet and a depth of 18 feet at mean low water. To extend this channel up to that wharf would require—

1. For a depth of 6 feet at mean low water, (thereby giving 15½ feet at mean high water,) the excavation of 120,000 cubic yards, the cost of which, estimated at 50 cents per cubic yard, would be	$60,000
Adding for contingencies 10 per cent	6,000
Total	66,000

Owing to the small amount of commerce of this port, and the small draught of the vessels (being chiefly fishing-vessels) that enter this part of the harbor, and to the fact that, if a channel were excavated there, the character of the material is such it is probable it would soon be filled up, this improvement is not, in my opinion, of sufficient importance to justify the expense of making it.

That part of the harbor which is the most deserving of attention with a view to its improvement, is that known as Miles Channel, (or South Channel,) which extends from the "Cow-yard" westward, by the southern point of Captain's Hill.

The petitioners of the town of Duxbury, in asking for the improvement of their harbor, had in view the enlargement of this channel at "Splitting-Knife Bar," and the point immediately below it. These bars are so formed as to render the channel narrow and crooked, and impracticable for the navigation of steamers up to the wharf on the southern point of Captain's Hill, the contemplated terminus of the Boston and Duxbury Railroad.

The general width of this channel is about 300 feet, and it is proposed to so enlarge it, at "Splitting-Knife Bar" and below, as to have a channel, at those places, 250 feet in width, and 8 feet in depth at mean low water. This will require the excavation of about—

45,000 cubic yards of sand and mud, which, at 40 cents per cubic yard, would cost	$18,000
For preservation of Duxbury Harbor	500
Adding for contingencies, say	1,500
Total	20,000

As stated by the United States deputy collector of customs, there was no revenue collected at that port during the fiscal year ending June 30, 1871, and the amount of commerce estimated by him for the same period was $60,000.

The following additional information is also furnished by him:

Plymouth and Duxbury Bay has ever been, from its peculiar location, a valuable harbor of refuge in case of storms, and has probably saved hundreds of vessels from being wrecked, and yet its real efficiency is not one-third part of what it might be if the channels were straightened and dredged from the "Cow-yard" through to Miles Channel, so that the vessels could run into the upper and more protected bay instead of being obliged to anchor in the "Cow-yard" and ride out the storm so badly exposed near the open ocean. The reasons for this will be shown by looking at the soundings of the harbor survey and noticing the crooks in the channel at this point which would prevent the possibility of running up in an easterly storm without exceeding the danger of being blown upon a lee shore.

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As an improvement for a harbor of refuge alone ten times the appropriation asked for might well be spent by the Government, for there is no place on the coast so admirably adapted for the purpose.

The past has fully proved this, with its loss of life and property on the coast. In addition to the ordinary coasting-trade, as well as a refuge for fishing-vessels in unfavorable weather, which sometimes number two hundred sail, the improvements in the harbor are needed for steamers which now, in summer, are constantly going into the bay, with passengers touching at the different points. A line of steamers is also very much needed to cross the outer bay from Provincetown, connecting with the new railroad from Duxbury to Boston. This line of steamers will be permanently established as soon as a channel can be straightened and dredged so as to enable them to run winters as well as summers.

The lumber and coal trade also demands the harbor improvement, from the fact that the coast for twenty miles east, as well as thirty miles west, to Boston, can best be supplied from vessels unladen at Duxbury, where there is a safe, sheltered, and cheap wharfage, and a channel free from ice in the winter.

By this means of transportation a great deal of time can be saved to navigation, as well as avoiding the dangers on the coast going up the bay to Boston, while a great pecuniary saving will be made in the distribution of the freight on the line of the railroad over and above reshipment of the same freights at Boston, if landed there, where wharfage is high and the difficulties of draw-bridges and overflowing docks are very great.

It is to be hoped that another branch of trade and commerce can be very much aided by the contemplated harbor improvements, viz, for the establishment of grain-elevators for the shipment of grain from Duxbury, which can be readily carried over the Western and Old Colony Railroad to that point, where vessels can receive it without the delays now incident to shipments at Boston, where there are few elevators for that especial purpose. At the present time I learn that there are two miles of loaded grain-cars from the West, lying between Boston and Brighton, on the track awaiting proper conveniences of shipment. It is estimated that all the freight could be more cheaply and expeditiously carried to and shipped from Duxbury, while the dangers of injury from exposure would thus be avoided, as well as in the saving of time.

In addition to this, a large iron-trade could be established at Duxbury, and manufactories, if a reliance could be had for freight, which could be easily obtained if the channel in the bay was properly dredged at the points intercepted by the two prominent sand-bars.

If the Cape Cod Canal shall ever be established, an inlet of refuge to the inner harbor can easily be cut west of Monument Point, thus furnishing an invaluable resort in time of danger for vessels going in or coming out of the canal in bad weather.

Respectfully submitted.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, December 14, 1871.

GENERAL: I have the honor to forward to you a map illustrating the survey made in Duxbury, Massachusetts, from July 6 to 20, 1871, in obedience to your instructions of June 17.

The map, on a scale of $\frac{1}{10000}$, shows the two harbors of Plymouth and Duxbury. The high and low water lines, as well as the 1, 2, and 3 fathom curves represented in the map respectively with a full black, a broken black, full green, red, and blue lines, are taken from the Coast-Survey map of Plymouth Harbor of 1857, on a scale of $\frac{1}{20000}$ twice enlarged, and from the hydrographical survey of Duxbury Harbor, by the United States Coast Survey, of 1867-'70, on a scale of $\frac{1}{10000}$. The survey is platted on this map, and the soundings (referred to mean low water) are drawn in blue figures. The points indicated with a red circle, marked in figures from 1 to 342, are soundings located on the map by two angles to three fixed points ashore. The figures in black are soundings copied from the Coast-Survey map of 1870.

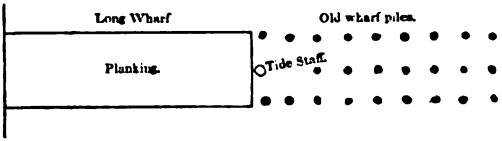
The survey was commenced by locating the fixed points from Gumet south light and Duxbury pier as a base. From these two points the following were determined by intersection: A and B, on Clark's Island; C, on Duxbury Beach; Duxbury belfry and Duxbury spire, hotel flag-staff, tree, and signal D, on Captain's Hill; Kingston spire, chimney on Plymouth rope-walk, Plymouth spire, Plymouth Beacon, on Plymouth Beach; new light-house, near Duxbury Pier, and fort flag-staff, on Sagnish Neck.

As a check on the accuracy of the previous determinations, angles were taken from each of these to all the other points visible from the station.

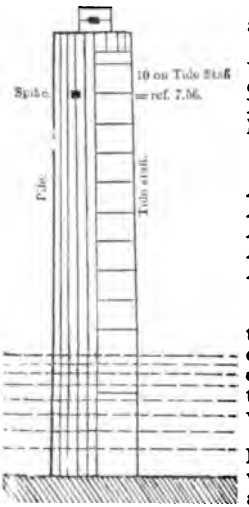
The plane of reference to which the soundings have been reduced is the mean of sixteen low waters observed in a tide-staff placed, as indicated in sketch, on Long Wharf, Plymouth Harbor.

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The bench-mark left was a spike driven in the pile even with the 10-foot mark on tide-staff; the reference of the spike is 7.56 above mean low water.



The number of soundings taken are 2[illegible] and the entire length of the lines in which these soundings are taken is twenty-[illegible] miles.



Of the above number of soundings 342 are located by [illegible] angles to three fixed points.

The following table gives areas in Duxbury Harbor northward of a line running thus: From Duxbury Pier north 65° east, (true bearing,) tangent to high-water line of Saquish Neck, and from Duxbury Pier north 52½° west, tangent to high-water line of Captain's Hill.

	A[illegible]
Area inclosed by the high-water line	[illegible]
Area inclosed by the low-water line	[illegible]
Area inclosed by the 6-foot curve	[illegible]
Area inclosed by the 12-foot curve	[illegible]
Area inclosed by the 18-foot curve	[illegible]

The mean rise and fall of tide is 9.3 feet, and it will be seen that nearly half of the harbor is dry at mean low water, [illegible] of these flats (shaded yellow in the map) being from 1 to 2 feet or more above the plane of reference. The flats, however, extend nearly to the 6-foot curve, and comprise an area of [illegible] whole water-area of the harbor.

The main channel, which at the entrance from Duxbury Pier to a point opposite the south part of Clark's Island is very deep, (the so-called lowland,) and at places 44 feet at mean low water, branches off in two, the eastern channel following Clark's Island and Duxbury Beach, and the western running at a distance 3,000 feet from Captain's Hill and the town. The western channel is of an average width of 400 feet, and has 18 feet of water at mean low water to within 3,500 feet of the wharf at Duxbury Point. The eastern channel is separated from the western by a bar running north and south of 500 feet width and with 12 feet of water on at mean low water. East and north of this bar the channel has 18 feet of water, and is of the same width as the western, extending northward the same length as the other. The area of these channels is only 500 acres, not $\frac{1}{10}$ part of the entire area of the harbor.

Little drains or guzzles in the flats (see the 6-foot curve) branch off from, and in case connect, these channels; but they are of no great importance for navigation. Their average width is 150 feet. To extend any of these, by dredging a channel 150 feet wide and 6 feet deep at low water through the flats, so as to bring 6 feet of water to the nearest wharf could not be done with less expense than $60,000. The most favorable location for such a channel is indicated on the chart with a red shaded parallelogram from the wharf at Duxbury Point to the 6-foot curve.

	Cubic [illegible]
The amount to be excavated in solid material is	[illegible]
For uneven dredging and loosening of material add 30 per cent	[illegible]
Total of excavation	[illegible]

From borings at various points at the flats (see diagram of borings at Stations I, II, III, IV) it will be seen that the bottom of the harbor through which the channel run is a hard tenacious clay slightly mixed with sand. The flats covering this stratum are clayey mud with only very little sand intermixed.

It is believed that the cost of dredging will be 50 cents per cubic yard, which in the above case, will amount to $60,000.

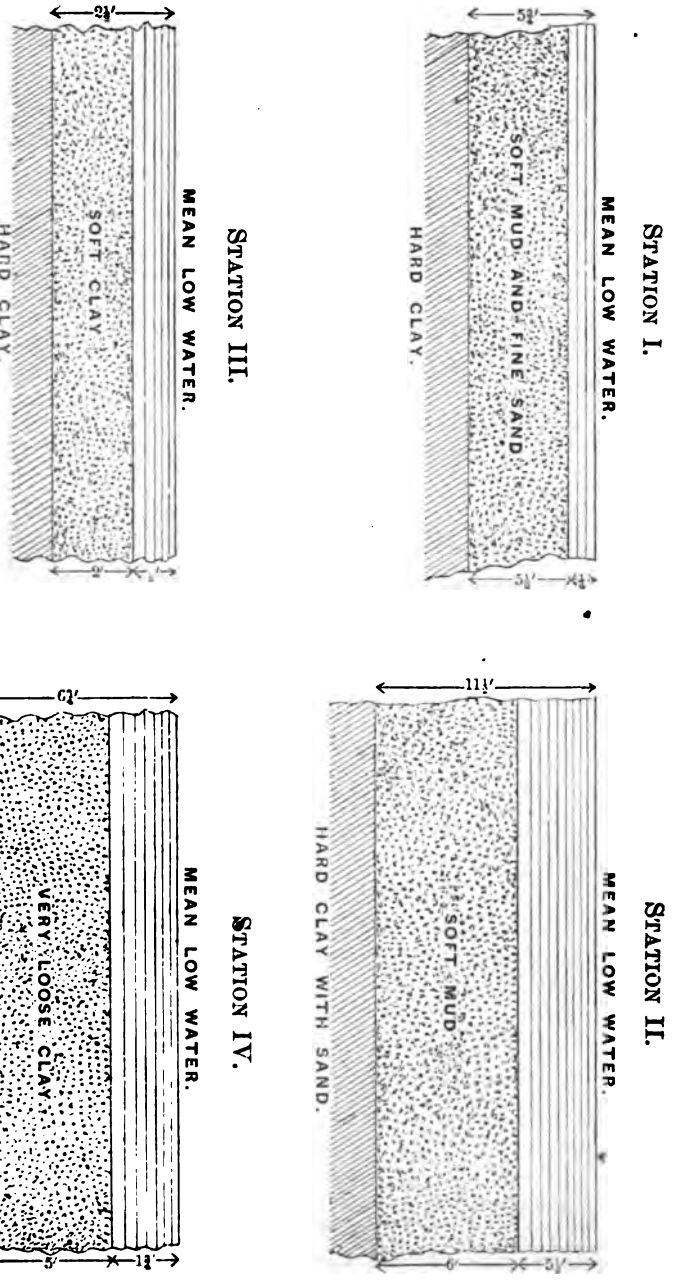
Estimate has been made for excavation of the same channel to a depth of [illegible] feet at mean low water, which would require 94,000 cubic yards of material excavated. As the material in this case would be easier to dredge, 2 feet of the harder would be avoided, a price of 40 cents per yard is estimated sufficient, and the cost of this channel would thus be $37,600.

According to your verbal instructions, given to me on your visit in Duxbury, I examined the channel running in continuation of the main entrance from Duxbury Pier up to Captain's Hill.

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Starting from a point three-eighths of a mile west of Duxbury pier, a bar runs across the mouth of this channel in a direction northwest-southeast; is 600 feet wide, with 15½ feet in its deepest part. West of this bar the channel runs north 70° west

Diagram of Borings.



(true bearing) to a point marked 337 on the map. This first part of the channel, the length of which is five-eighths of a mile, is 400 feet wide, and its depth varies from 20 to 41 feet at mean low water; thence it runs north 17° west to a point marked 322

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a distance of seven-eighths of a mile, having no less than 16 feet at mean low water along the line of greatest depression. Here the channel turns abruptly to the westward, with 18½ feet in its deepest part as far as examined, viz, point 319, 800 feet distant from the south point of Captain's Hill.

Very respectfully, your obedient servant,

SOPHUS HAAGENSEN.

Brevet Brigadier-General GEORGE THOM,
Lieutenant Colonel, Corps of Engineers, Portland, Maine.

To the honorable the Senate and House of Representatives of the United States of America:

Your petitioners, citizens of Duxbury and vicinity, interested in the proper navigation of the Plymouth, Duxbury, and Kingston Bays, so called, would respectfully represent that one of the channels in said bay, between the southerly point of Captain's Hill, so called, and the monument or pier upon which the new light-house is to be erected, is obstructed by a sand-bar, which, if properly dredged out, would give a good channel of from 13 to 15 feet of water at low tide, as shown by the map of the Coast Survey made the past season, to which you are respectfully referred for full particulars of the amount of dredging necessary to be done.

Your petitioners would most respectfully ask that an appropriation be made by Congress for this purpose, and, as in duty bound, would ever pray, &c.

S. N. Gifford.	Henry A. Prior.	Briggs B. Delano.
William Prior.	Ziba Hunt.	Henry Paulding.
George H. Bailey.	Levi H. Cushing.	George S. Weston.
Samuel Atwell, jr.	Lebbeus Harris.	Gaspour Holmes.
John A. Hall.	Joseph M. Harris.	Edmund H. Sears.
Luther Pierce.	Otis Delano.	Stephen H. Jackson.
Andrew Northey.	Gustavus D. Simmons.	Jabez Hatch.
Nathan Doner.	F. P. Sherman.	Weston Freeman.
George L. Higgins.	T. R. Eames.	Abel Richmond.
John W. Brewster.	G. K. Ryder.	Alden Cushman.
C. H. Bradford.	F. Bryant.	Elbridge G. Morton.
Marcellus Soule.	Issathof Josselyn.	George B. Cushing.
William Mack.	Rodney M. Leach.	John K. Parker.
Clarence M. Smith.	J. P. Loring.	George P. Prior.
Harrison G. Freeman.	George Sprague.	Samuel Stickney, 2d.
David H. Freeman.	Thomas Gorham.	Orson M. Arnold.
Frank Lewis.	Andrew E. Paulding.	Melsan Hunt.
Gamaliel Wadsworth.	Allen Chandler.	Pelham Chandler.
John Wilde.	Edgar Chandler.	Henry Chandler.
Charles Windsor.	J. W. Swift.	William Simmons.
Harvey Soule.	Lot Swift.	Edwin I. Simmons.
Joshua Winsor.	Hiram Simmons.	Thomas B. Delano.
Leander B. Pierce.	Edwin A. Soule.	James H. Freeman.
Duva Wadsworth.	John E. Hutchins.	Bradford Weston.
Alfred Sampson.	Charles Delano.	Thomas R. Hutchins.
George F. Wadsworth.	Lyman Drew.	Edgar Swift.
Samuel Holmes.	George W. Curtis.	Wyman T. Weston.
Richard A. Winsor.	Lorenzo S. Chandler.	E. Freeman.
Asa Brewster.	Edwin Prior.	E. Sampson.
Allen Prior.	James Perry.	George Childs.
Harrison Chandler.	Geo. Roland Freeman.	Morton Alden.
Allen Holmes.	William W. Holmes.	George P. Freemas.
Jerome Chandler.	John P. Romaine.	George T. Perry.
Harrison G. Weston.	Rufus Pierce.	Joseph W. Hunt.
John E. Hamilton.	Richard B. Chandler.	Frank. E. Wadsworth
John Merritt.	John Waterman.	James G. Perry.
Elephy Prior.	J. G. Gross.	George F. Freeman.
James M. Weston.	Andrew Stetson.	Micah Laub.
William Sheldon.	W. S. Freeman.	John E. Joslyn.
John P. Bradley.	E. W. Paine.	Micah A. Soule.
Thaddeus W. Chandler.	J. W. Hathaway.	Tobias Sanders.
William Pauldy.	George Winsor.	George Bradford.
Samuel W. Hunt.	Henry W. Hathaway.	George London.
Josiah Peterson.	H. L. Sampson.	Melzar Brewster.
G. W. Hawkes.	J. W. Standish.	Bradford Freeman.
W. F. Sherman.	Nathanial Delano.	Edwin Hunt.
Fred. H. Henshaw.	Zenas Yeaman.	Cassius Hunt.
Henry Dunster.	Joshua S. Freeman.	Stephen M. Allen.
Henry M. Freeman.	Charles C. Weston.	

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V 30.

SURVEY OF WELLFLEET HARBOR, MASSACHUSETTS.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, November 3, 1871.

The survey of this harbor, called for by act of Congress of January 31, 1871, has been made, with a view to ascertaining the nature and extent of the obstructions to its navigation, as well as to making an estimate of the cost of its improvement.

Mr. Sophus Haagensen, civil engineer, was assigned to the charge of this survey, which he has completed in a very creditable and satisfactory manner. His report thereon, dated the 31st of October, 1871, together with two maps and the papers therein referred to, are herewith submitted, with my approval of same, and with the recommendation that the several sunken rocks named as obstructing the channel should be removed, and that the channel be deepened to a width of 150 feet, so as to give 4 feet of water, at mean low water, (being 15 feet at mean high water,) up to the wharves of the town.

The estimated cost of these improvements is as follows:

1. For excavation of easterly channel to Central and Commercial wharves for a length of 2,060 feet, 35,413 cubic yards, at 40 cents	$14,165 20
2. For excavation of westerly channel for a length of 1,400 feet, 21,840 cubic yards, at 40 cents	8,736 00
3. Removing five of the most dangerous of the sunken rocks, containing 204 cubic yards, at $20	4,080 00
Contingencies, say	3,018 80
Total	30,000 00

This amount could be profitably expended upon the work during the next fiscal year.

This harbor is situated near the northern extremity of Cape Cod, and is one of the best and safest harbors upon the cape.

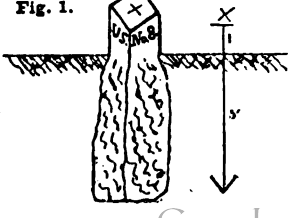
The accompanying statement, furnished by the United States deputy collector of customs of the port, exhibits the importance of this harbor and the extent of its commerce, from which it appears that it is confined chiefly to mackerel fishery, while, as reported by the deputy collector, there is little or no revenue derived from imports.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, October 31, 1871.

GENERAL: I have the honor to forward to you two maps illustrating the survey of Wellfleet Harbor, Massachusetts, made from June 19 to June 30, 1871, in accordance with your instructions of June 17.

The survey consists of a hydrographical survey of the upper part of the harbor north of buoy No. 3, and a survey of the rocks most dangerous to navigation. As no bench-mark was left from the last survey of the harbor, made by the United States Coast Survey in 1850, the plane of reference to which the soundings were reduced was taken as the mean of eighteen low waters, observed on the tide-staff established at the end of Central Wharf from June 19 to June 30, inclusive.

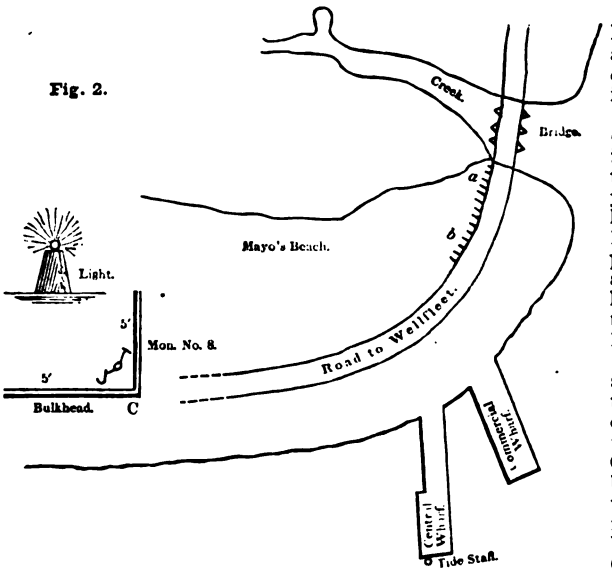
Fig. 1.



A granite monument, Fig. 1, 6 inches by 6 inches, 6 feet long, marked "U. S. No. 8," has been put 55 feet southeast of Mayo's Beach light, 5 feet from the bulkhead round the light-house. The top, straight-hammered, is 1 foot above the level of the beach, and 14.759 feet above the plane of reference to which the soundings are reduced, this mean low water being zero.

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Fig. 2.

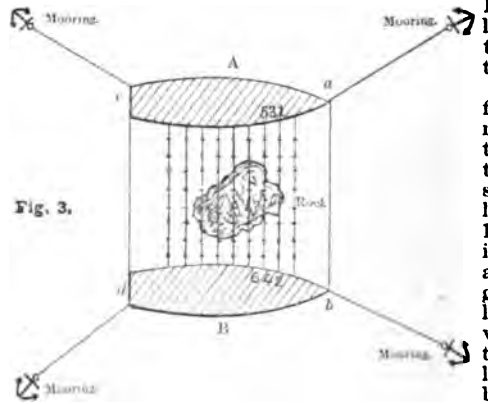


C, top of the bulkhead, is 16.698 feet above mean low water: *a* and *b* are marks cut in a fence on the road to Wellfleet, (as indicated in Fig. 2,) showing, *a*, the highest high tide in the last six years; *b*, the highest high tide in the spring of 1871. These marks were pointed out by a reliable man, and the height above zero determined thus: $a = 13.658$; $b = 13.211$.

A projection of the triangulation stations on the Coast-Survey map of 1850 (scale 1: 20,000) was obtained from the Coast-Survey Office, but as only three of these could be identified, viz, Mayo's Beach light, South Wellfleet Congregational spire, and North Wellfleet Methodist belfry, signals A, B, C, D, and G were erected and located by sights from Mayo's Beach light and South Wellfleet church as a base-line.

The soundings are located on the map by two angles observed simultaneously with sextant, to three of the fixed points ashore. For surveying the rocks, two vessels A and B, were moored parallel to each other on both sides of the rock, as shown in sketch Fig. 3, and soundings taken in the lines 1–2, 3–4, &c. The position of the vessels was determined by angles to fixed points ashore.

Fig. 3.



Plan I is a general plan of Wellfleet Harbor, showing the entire channel from the entrance buoy No. 1 to the end of Billingsgate Shoal up to the wharves on Mayo's Beach. The soundings are expressed in feet below mean low water, to a depth of 18 feet; beyond this depth the soundings are given in fathoms. The 1- and 3 fathom curves are drawn in green, red, and blue lines. North of line *f g* the soundings from this survey are shown in blue figures and the fathom-curves are drawn in red lines; the dotted green, red, and blue lines are the 1, 2, and 3 fathom curves of 1850. The rocks surveyed in 1871, viz, Channel Rock, Lobster Rock, Lumpfish Rock, Mayo's Rock, and Bay Rock, are marked *a*, *b*, *c*, *d*, and *e*. The scale of this map is 1: 20,000.

Plan II shows the special survey of the upper part of the harbor, north of buoy No. 3, and the shape of the five above-named rocks. The soundings of 1871 are all shown in black figures. As in Plan I, full green, red, and blue lines, are 1, 2, and 3 fathom curves of 1871; dotted red, green, and blue lines, are 1, 2, and 3 fathom curves of 1850.

As the wharves only extend to the low-water line, vessels cannot be brought up to these except at full tide; and must await this, anchored up in the part of the harbor called "Deep Hole," about a mile south of the three principal wharves. As these could not by any reasonable extension be brought to deeper water, the dredging of a channel is the only means to facilitate shipping.

Two different channels are marked on Plan II; one, the easterly, from the 6-foot curve up to Central and Commercial wharves; and one, the westerly, from the 4-foot curve up to Mercantile wharf; and an estimate made for the amount of excavation required to procure a depth from 2 to 6 feet at mean low water in the easterly, and from 2 to 4 feet in the westerly. One hundred and fifty feet at the bottom is con-

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sidered sufficient width, giving ample room for two schooners with tug-boats alongside to pass each other.

The depth to which the bottom of channel ought to be dredged below mean low water depends upon the draught of the vessel to be brought through the channel, and the number of hours of every tide the channel is required to have sufficient water to float the vessels.

According to the tide-observations from June 19 to 30, the mean of twenty high waters was 9.73 feet, mean low water being zero. These tides were neap-tides.

According to observations made by United States Coast Survey, the mean rise and fall of neap-tides is 9.40 feet; mean rise and fall of spring-tides is 13.30 feet; mean rise and fall of all tides is 11.20 feet.

To allow vessels of 9-foot draught, which is about the average of the fishing-schooners belonging to this harbor, to float in the channel during the last three hours of the flood and the first three hours of the ebb, *i. e.*, six hours out of every twelve, excavation to 4 feet below mean low water would be sufficient.

The bottom of the whole harbor chiefly consists of white sand; in some spots a thin layer of mud is found, and granite bowlders are scattered over the flats; but along the line where the channel is proposed the bottom is all sand; no bowlders were met with; and soundings made with a pointed iron rod showed sand to the depth of 10 feet.

The following table gives the amount of excavation required for an easterly channel from Central Wharf to the 6, 5, 4, 3, and 2 foot curves, and for the westerly from Mercantile Wharf to the 4, 3, and 2 foot curves. In the fourth column is the volume in cubic yards as calculated from the map. In the fifth, the figures from the fourth column are increased 30 per cent., allowing this for uneven dredging and loosening of the excavated material, thus giving the actual volume measured in the scows. In the sixth is the cost of excavation, 40 cents per cubic yard being considered the price for which dredging can be done, supposing the dumping place is chosen in a convenient distance from the channel.

Channel.	Depth of channel at mean low water.	Length of channel.	Amount of excavation in cubic yards as calculated.	Amount of excavation in cubic yards measured in the scows.	Cost of excavation.
	Feet.	*Feet.*			
East channel	6	3,380	59,622	77,510	$31,004 00
Do	5	3,300	41,574	54,046	21,618 40
Do	4	2,060	27,241	35,413	14 165 20
Do	3	2,000	16,550	21,515	8,606 00
Do	2	1,200	7,600	9,880	3,952 00
West channel	4	1,400	16,800	21,840	8,736 00
Do	3	1,340	8,200	10,600	4,240 00
Do	2	600	3,800	4,940	1,976 00

Rocks to be removed in the lower part of the harbor.—Channel Rock is the most dangerous and the largest of the rocks in the channel at the entrance of the harbor, off Billingsgate Point, in 12½ feet of water, (at mean low water,) and with only 1.9 feet on the shallowest part of it. Its greatest dimensions are 20 feet by 19 feet by 10½ feet height. Its cubic contents are 92 cubic yards. This, as well as the following bowlders, are all hard gray granite.

Lobster Rock is a column-shaped bowlder situated in the middle of the channel east of Billingsgate light, in 18 feet of water, with 4.5 feet of water on it. Greatest dimensions 13½ feet by 10½ by 14 feet height. Cubic contents 60 cubic yards. Both rocks are buoyed out.

Lumpfish Rock is a small bowlder, 600 yards north-northeast of Lobster Rock buoy. It is situated in 9 feet of water, having 3.5 feet on top of it. Dimensions, 10 feet by 6 feet by 6 feet height. Cubic contents 12 cubic yards.

Rocks to be removed in the upper part of the harbor.—Mayo's Rock, 40 feet west of buoy No. 7, is a pyramidal-shaped rock, near the best anchorage-ground of the harbor. It has only 2.7 feet of water on the shallowest part at low water, and the depth round it is about 8 feet. Greatest dimensions are 13½ feet by 9 feet by 5 feet height. Cubic contents 20 cubic yards.

Bay Rock is a wedge-shaped bowlder, in 6 feet of water; it is awash at low tide. Dimensions 15 feet by 8 feet by 9 feet height. Cubic contents 20 cubic yards. It ought to be removed as being inside the 6-foot curve. It is estimated that the rocks can be removed by drilling and blasting, or by surface-blasting alone, the fragments

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hoisted on board a vessel, and dumped ashore, at an average cost of $20 per cubic yard, which gives the following figures for removal of—

Channel Rock, 92 cubic yards, at $20 per cubic yard	$1,840 00
Lobster Rock, 60 cubic yards, at $20 per cubic yard	1,200 00
Lumpfish Rock, 12 cubic yards, at $20 per cubic yard	240 00
Mayo's Rock, 20 cubic yards, at $20 per cubic yard	400 00
Bay Rock, 20 cubic yards, at $20 per cubic yard	400 00
	4,080 00

Estimate of the cost of procuring a depth of 4 feet at mean low water, or 15 feet at mean high water up to the wharves, and removing the rocks obstructing the channel in Wellfleet Harbor, Massachusetts.

For excavation of an easterly channel to Central and Commercial wharves to a depth of 4 feet at mean low water, width of 150 feet, and length of 2,060 feet, 35,413 cubic yards, at 40 cents	$14,165 20
For excavation of a westerly channel, same depth and width, 1,400 feet length, 21,840 cubic yards, at 40 cents	8,736 00
Total for dredging	22,901 20
Removal of five of the most dangerous rocks, 204 cubic yards, at $20	4,080 00
	26,981 20
Contingencies 11 per cent	3,018 80
Grand total	30,000 00

Inclosed please find a letter from the deputy collector of the port, Mr. Simon Atwood, and another from the citizens of Wellfleet, giving statistics in regard to the business of the town.

I remain, general, very respectfully, your obedient servant,

SOPHUS HAAGENSEN,
Assistant Engineer in charge of Survey.

Brevet Brigadier-General GEORGE THOM,
Lieutenant-Colonel, Corps of Engineers, Portland, Maine.

CUSTOM-HOUSE, *Wellfleet, July 7*, 1871.

DEAR SIR: I herewith transmit a few statistics showing the matter relative to our harbor, as we understand it. It is life or death with us whether this thing be done. Hope our Government will get the proper understanding of our necessities, and I am sure if they do an appropriation will be forthcoming.

I am, respectfully,

SIMON ATWOOD,
Deputy Collector, Port of Wellfleet.

Mr. HAAGENSEN.

The port of Wellfleet numbers about 2,300 inhabitants, whose almost exclusive business is the mackerel fishery. There are about 100 vessels belonging to and sailing from this port, whose value may be estimated at $600,000, tonnaging not far from 10,000 tons, and employing 1,200 men as seamen. To man these vessels, large draughts have to be made upon other towns and various portions of the country.

The gross amount of the sea produce is not far from $500,000 annually. With this amount of tonnage, and keeping in mind the fact that the trips of the fishermen do not average over three weeks in duration, and that many other vessels besides those actually owned here frequent this port to bring coal, wood, barrels, &c., and to carry away the fish caught, it can easily be estimated that more than 1,000 sail pass any given point at the entrance of this port during the season. These vessels carry valuable cargoes and many passengers, and it is very important that navigation of the port should be unimpeded by sand-bars or rocks.

Scattered over the bay are many rocks, single bowlders. Some of these are particularly dangerous; others, by lying upon one side or the other of the bay, can be avoided. Among the dangerous rocks may be classed the Point Channel Rock and Mayo's Rock. These, which are nearly or quite awash at very low tides, call for removal. Only last

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year a new vessel, entering the harbor, ran full upon the Point Channel Rock, staving her bows. The attention of the proper authorities is called to the state of the upper harbor, where the wharves project into the same.

Years ago, when the fisheries had not reached their present respectable and important standing among the industrial pursuits of the country, a few straggling fishermen picked up a scanty subsistence from the sea in their little boats, or diminutive vessels. Craft of more than 65 tons were rarely seen, and the average was not over 40 tons. For a long time this state of things continued; the fishermen, being poor, were content with a poor living. With this class of vessels the harbor was capacious and safe; of light draught, they experienced no difficulty in their passages, and short and comparatively cheap wharves answered their every purpose. In these latter days the scene has essentially changed; the impulse that has been exhibited in business during the last ten years has communicated itself in a remarkable manner to the fishermen, and the craft of thirty years ago are among the things that are past. Fishing has been reduced to a science, and is now pursued in beautiful and costly clipper schooners, each one a yacht, of heavy draught and great speed, this latter property being considered an essential element to success, to attain which it has been found necessary to increase the draught. Our wharves, which were then abundantly able to accommodate the primary class of vessels, became totally useless to the succeeding generation, and, as a consequence, had to be pulled down or extended toward deep water. As the vessels could not come to the wharves, the wharves must go to them. This has been done so far as practicable, but the particular configuration of our harbor is such, and the flats extend so far from the shore, that it is impossible, with any reasonable degree of expense, to bring our wharves to deep water. What, then, we would respectfully ask of the Government is that it will lend us its powerful aid to bring the deep water to our wharves.

Wellfleet has the only natural and safe harbor on Cape Cod, except Provincetown, and exceeds that in safety.

By vigorous efforts and much sacrifice a railroad has been constructed to this town, so that the harbor is as convenient for the seamen of the upper towns of the cape as for Wellfleet, none of them being over one hour from this place.

With proper facilities, there is everywhere indication of growing prosperity. Our young men are becoming ambitious and enterprising, and no longer are willing to plow with the same instruments as did their fathers. Nothing will so loosen their fetters as a few additional feet of water. Delay they cannot abide. To no class is time of more importance than to the fisherman; his voyage is often made or lost in a day.

Deep water enters largely into the composition of a good seaman. If the Government depends upon us to turn her out able seamen when her emergency comes upon her, let her furnish us the principal element, viz, deep water, and we promise not to disappoint her.

Hoping that the proper authorities will, while granting our request, excuse our importunity, we shall ever remain your obedient debtors.

THE CITIZENS OF WELLFLEET.

V 31.

WAREHAM HARBOR, MASSACHUSETTS.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, December 7, 1871.

The survey of the harbor of Wareham, Massachusetts, has been made, in compliance with a resolution of the House of Representatives, "with a view to dredging the same and fitting it for a harbor of refuge;" and the following report is respectfully submitted "upon the feasibility and probable cost thereof," as required by said resolution.

Mr. Sophus Haagensen, civil engineer, was assigned, under my instructions, to the charge of this survey, which he has completed in a very creditable and satisfactory manner. His report thereon, dated November 28, 1871, together with the three drawings therein referred to, (also prepared under my instructions,) are herewith submitted, with my approval of the same, and with the recommendation—

1st. That a channel be excavated for a distance of 1,300 feet across Quahaugh Bar, to a width of 250 feet, and to a depth of 9 feet at mean

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low water, giving thereby 13.2 feet at ordinary high water, the channe. to be located as indicated on Plan I.

2d. That the present channel, immediately below the Franconia Iron-Works, be widened as indicated on Plan I, and also deepened to a depth of 9 feet at mean low water, by which improvement vessels could, with ease and safety, ascend to the wharves at Wareham with that depth.

3d. The removal of a sunken ledge and bowlder from the channel of Weweantit River, which, uniting with Wareham River, forms an extension of the harbor of Wareham.

The estimated cost of these improvements is as follows, viz:

1. Dredging channel, as above, across Quahaugh Bar, 41,260 cubic yards, at 45 cents per cubic yard	$18,567 00
2. Widening and deepening channel below Franconia Iron-Works, 45,300 cubic yards, at 45 cents per cubic yard	20,385 00
3. Removing ledge and bowlder in Weweantit River, 150 cubic yards, at $20 per cubic yard	3,000 00
Contingencies, say	3,048 00
Total	45,000 00

This amount could be profitably expended upon the improvement of this harbor, for its completion during the next fiscal year.

The following information in regard to this harbor has been furnished me by the United States deputy collector at that port, viz:

The amount of revenue collected at the port of Wareham for the fiscal year ending June 30, 1871, was $1,492.09. The commerce of Wareham is chiefly connected with the manufacture of iron, and depends largely upon the transportation of the materials used therein, which amount to about 50,000 tons yearly, to which may be added about 10,000 tons of other articles of commerce.

This business is done by vessels of from 200 tons to 400 tons burden, drawing from 12 to 14 feet of water, and great delay and expense are often incurred by the larger vessels from the intricate navigation of the river, rendering it especially difficult to get vessels to bring coal from the British provinces; in fact, a large portion of the foreign coal used in our factories is landed at Fairhaven, and carried thence by rail to its destination.

If the channel of Wareham River could be straightened and deepened, it would much facilitate transportation and cheapen its cost, thereby encouraging our manufacturers to increase their business to the full capacity of their works, and offering inducements for the building of others.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, November 28, 1871

GENERAL: I have the honor to forward to you three drawings, illustrating the survey made in Wareham, Massachusetts, in obedience to your written instructions of September 29.

A copy of the survey made in 1870, by Professor Henry L. Whiting, for the board of harbor-commissioners, was obtained from their office, and ranges established in which additional soundings were made. These ranges were located in the map from the following fixed points, remaining from the survey of 1870, marked in Plan I as A, B, C and K; the soundings in the new lines are all drawn in blue figures on Plan I, and are referred to mean low water, this plane of reference being established last year from a month's observations on a tide-staff placed on the wharf outside the Franconia Iron-Works. The tide-staff could not be replaced there this year, as the wharf was under repair, but was placed in B, 865 feet northwest of the old tide-staff; from the observations in B the soundings were reduced. Another tide-staff was put at A, north of the Cape Cod Railroad-bridge, and levelings made between these three mentioned points.

The plane of mean low water is 5.70 feet below the top of the cap of the wharf outside the Franconia Iron-Works, in the place marked in Plan I as *old tide-staff*. For safety the height of the top of the foundation-stone, on the northwest corner of the Franconia Iron-Works, was determined as 8.35 feet above this plane of reference.

The zeros of tide-staves A and B are respectively 1.737 and 3.998 feet below mean low water.

Current-observations were made from buoy No. 3, on the southerly side of Quahaugh Bar, (Plan I,) and from the Cape Cod Railroad-bridge, between tide-staves A and B

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The float used was a hollow tin cylinder 6 feet long, 3 inches diameter, loaded so as to be nearly submerged; the log-line attached to it was marked so as to read the velocity of the current in nautical miles and tenths per hour. The float was allowed an outrun of 30 seconds, and the corresponding length of a knot; consequently $\frac{6085 \cdot 4}{120} = 50.72$ feet. From station-buoy 3 the velocities were thus determined:

EBB.		FLOOD.	
First quarter	0.45	First quarter	0.15
Second quarter	1.00	Second quarter	0.25
Third quarter	0.70	Third quarter	0.60
Fourth quarter	0.10	Fourth quarter	0.40

The directions of the current, observed by the angle of each outrun with a fixed point ashore, are indicated in Plan I by blue arrows.

The current-observations from the railroad-bridge are illustrated by a diagram, Plan III, showing velocities during one ebb and one flood, and simultaneous tide observations on the two gauges A and B.

The present channel, shown on the map, Plan I, by a broken blue line, (the 9-feet contour line,) needs straightening at two points, viz, at the Quahaugh Bar and at the flats extending south of the Franconia Iron-Works. The widening of the channel, by dredging off the easterly spit of Quahaugh Bar, would only be an imperfect improvement, as a dangerous shoal always would remain. The dredging of a channel across Quahaugh Bar, 250 feet wide, and 9 feet deep at low water, indicated on the map by red shaded part, would allow vessels coming in, west of Long Beach, to reach the deep water north of Quahaugh Bar, (see 12-feet contour line,) without changing their course by going east of the three buoys now marking out the extremity of this bar. The mean rise and fall of tide is 4.2 feet, which would give 13.2 feet of water in the channel at high water.

This channel, the length of which would be 1,300 feet, would require the removal of 41,260 cubic yards of sand, mixed with clay, 30 per cent. being allowed for loosening of material and uneven dredging.

It is believed that the current now running in the direction of the proposed channel with a velocity of 1.00 and 0.70 knots per hour during second and third quarters of the ebb, and a velocity of 0.60 and 0.40 during third and fourth quarters of the flood, would always keep this channel open. The present channel might be closed by dumping of the excavated material in its narrowest place, in line C B east of the spit at *e*, thus guiding the main body of the ebb-current into the northern part of the proposed channel.

Dredging off the areas indicated in Plan I by blue-shaded part would widen the now existing channel to 300 feet in its narrowest part, and allow vessels to go from the straight course south of the flats to the one north of them, through a curved line of 1,400 feet length, and a radius of 1,000 feet, whereas they now have to sail in a curved line of 1,500 feet length, and a radius of 550 feet.

The amount of excavation required here to procure a depth of 9 feet at mean low water over the areas shaded blue would be 45,300 cubic yards of the same material as in the Quahaugh Bar, sand mixed with clay, 30 per cent. being allowed as before, for loosening of material and uneven dredging.

An examination was made of a ledge and a bowlder seriously obstructing the entrance of the Weweantit River. The iron-works situated on this river must bring their vessels loaded with iron and coal to the wharves in Wareham Harbor, and carry the material in scows down the Wareham River round Cromset Neck, and up the Weweantit River. If those before-mentioned obstructions of the channel were removed, vessels drawing 11 feet would be able to enter at all stages of tide, and go to a wharf proposed to be built as indicated on Plan II. This wharf would be easier to reach for vessels than the wharves in Wareham Harbor, and four miles of scowing would be saved.

The bowlder is situated in the middle of the channel in 11½ feet of water at mean low water, and has only 2½ feet of water on its highest part. Its cubic contents are 10 cubic yards. The ledge extends parallel to the channel, a distance of 52 feet, and a width of 15 feet, has 11½ feet of water around it at mean low water, and 6½ feet of water on top. The amount of rock to be removed to procure a depth of 11½ feet at mean low water over this ledge would be 140 cubic yards.

Estimate of cost of improvement of Wareham River, Massachusetts.

Dredging of a channel across Quahaugh Bar, 1,300 feet long, 250 feet wide, 9 feet deep at mean low water. Amount of excavation, 41,260 cubic yards, at 45 cents	$18,567 00
Widening the channel by dredging off the flats south of the Franconia Iron-Works. Amount of excavation, 45,300 cubic yards, at 45 cents	20,385 00
	38,952 00

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Contingencies, 8 per cent	$3,048 00
Total	42,000 00

Improvement of Weweantit River, Massachusetts.

Removal of bowlder, 10 cubic yards, at $20	$200 00
Removal of ledge, 140 cubic yards, at $20	2,800 00
Total	3,000 00

Very respectfully, your obedient servant,

SOPHUS HAAGENSEN.
Assistant Engineer in charge of Survey.

Brevet Brigadier-General GEO. THOM,
Lieutenant-Colonel, Corps of Engineers, Portland, Maine.

V 32.

EDGARTOWN HARBOR, MASSACHUSETTS.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, May 10, 1872.

In obedience to instructions contained in Department letter of the 8th ultimo, and in compliance with the resolution of the House of Representatives, dated April 5, 1872, a survey has been made of the harbor of Edgartown, Massachusetts, "with a view to dredging and improving the same so as to afford greater protection and facilities to commerce:" and, as further required, the following report is respectfully submitted "upon the feasibility of making such improvement, and the probable cost thereof."

The memorial presented to Congress by the board of harbor-commissioners of the Commonwealth of Massachusetts, with the several papers and map of the harbor accompanying same, furnished me for my information in the matter, have been carefully examined, and the harbor has since been visited by me. The information contained in the memorial and papers accompanying it is such as to have made it necessary to obtain but little additional for compliance with the requirements of the resolution. From this memorial (dated January 10, 1872) it appears that "about two years ago, during a violent gale, the southern inlet to the harbor of Edgartown was wholly blocked up by masses of sand driven in by the sea. This event not only deprived the local community of a direct communication with valuable fishing-grounds, (to the southward,) and lost to stranger vessels approaching from sea a means of obtaining pilots before venturing across the shoals or through the dangers of Muskeget Channel, but it so changed the regimen of the currents in the harbor itself that the main channel, directly in front of the town, began to become narrower and more shallow."

On referring to the map and reports accompanying the memorial it will be seen that the beach, which now obstructs the passage from the inner harbor southward to the ocean, is about three and one-half miles in length, with an average width of about 450 feet; that this beach has been beaten bodily northward, since 1846, a distance about equal to its width; that the outlets through the beach to the ocean have changed their locality from time to time during the present century, with a general movement eastwardly, the last opening being at its eastern ex-

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tremity, where it was closed in 1869, thereby forming a continuous beach from west to east—a state of things which, according to tradition, has not existed since the early part of this century.

With a view, therefore, to "restoring the former regimen of the currents," so as "to maintain all the advantages that have distinguished this harbor," as set forth in the memorial, an appropriation is therein asked to be made, during the present session of Congress, "for re-opening the southern passage-way from the harbor of Edgartown to the ocean."

As to the necessity of re-opening at once a southern inlet for the preservation of this harbor, there can be no possible doubt, not only in order to prevent further injury from its filling up, (as already experienced since the closing of the southern inlet in 1869,) but also to restore the harbor to its former condition and usefulness. It is believed, however, "that the new inlet will repeat the history of those which have before existed, shifting eastward and ultimately closing; but the remedy may always be repeated, and will never be expensive," in consideration of the vast benefits to be derived therefrom.

In order to ascertain the character and quantity of the material to be excavated, and to determine the most advisable location of the proposed opening through the south beach, near its western extremity, as well as to ascertain what changes, if any, have taken place in the beach since the survey was made last season, (changes which were supposed to have been caused by the extraordinary storm of the 15th of November last,) a resurvey has been made with special reference to those points.

Mr. Sophus Haagensen, civil engineer, was assigned by me to the immediate charge of this survey. His report of same, dated May 8, 1872, together with the map therein referred to—both made under my special instructions—are herewith submitted, with my approval.

By comparing this map (marked I) with the map accompanying the memorial of the harbor-commissioners, (marked II,) it will be seen that the changes which have occurred along the south beach where resurveyed, have been unimportant.

The channel which, in my opinion, is the most feasible and desirable to have opened, is shaded in red on the accompanying map I. This would guide the tidal currents in the shortest and most direct course from Cotamy Point to the ocean, and would not, like the crooked channel west of it, be liable to be closed by eddies formed by the ocean-swells; and, as shown by the survey, the quantity of excavation required would be smaller than for a channel at any other place to the westward of it; moreover, on passing the south beach, it would sooner enter the deep water of the ocean, without encountering the breakers indicated on the harbor-commissioners' map.

Estimates have been made for both the eastern and western channels, (shown in the drawing,) and for widths of 100, 200, and 300 feet, (allowing for a side-slope of 45°,) and to a depth of 4 feet at mean low water, all that is required either for the scour of the tidal currents or for the passage of the small boats such as are generally used by the fishermen and the pilots at that place.

The exposure of this beach to the ocean storms, and the consequent liability to difficulties and interruptions in opening a channel through it, render it advisable, in my opinion, to open by excavation as much of the channel as is practicable, so as to favor, as much as possible, the action of the tidal currents in their completion of the work. The estimates have, therefore, been made to include the excavation, by dredg-

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ing, of all the material (coarse sand) to a depth of 4 feet below mean low water southward to within 50 feet of the high-water line of the ocean, all above high water (on the beach) to be removed (at a less expense) by barrows or carts.

In the report of Mr. H. L. Whiting, which accompanies the memorial of the harbor-commissioners above referred to, he recommends that the width of the new inlet should be about 300 feet, which "is about equal to the narrowest section of the natural passage-way between the harbor and bay," and "is not wider than is desirable for a beating-channel," in which I fully concur. But, as it is highly important for the preservation of this harbor that an opening should be made this season, so that the harbor may derive immediate benefit from the scour of the tidal currents, and as there may also be some doubt as to the complete success of this undertaking, it is respectfully recommended that the proposed channel should be first opened to a width of 150 feet only, to be afterward increased to a width of 300 feet for purposes of navigation. It is, however, more than probable that, on once making an opening to a width of 150 feet, as proposed, the action of the tidal currents (as shown by Professor Mitchell in his report accompanying the memorial of the harbor-commissioners) would operate to singular advantage at this place, and would increase the channel, in part if not fully, to the desired width of 300 feet. An estimate is therefore made, for this season, for a channel 150 feet in width only, which is as follows, viz:

1. 34,000 cubic yards excavation, by dredging, at 50 cents	$17,000
2. 10,000 cubic yards excavation, with carts and barrows, at 30 cents	3,000
Adding for contingencies, say	2,000
Total	22,000

The importance of this harbor is stated in the memorial of the harbor commissioners, as follows, viz:

As a port of refuge, this harbor, from its peculiar situation, has been of inestimable value to maritime commerce.

The southeastern coast of Massachusetts is the most dangerous portion of the Atlantic shore. Its widely-extended shoals and its bewildering currents have been the dread of the mariner since the earliest settlement of our country. Lying so near the track of much of the foreign commerce of the country, as well as in the route of a vast coastwise trade, its dangers must be braved every day of the year by a fleet of merchant-vessels larger, it is said, than any other in the world. In the midst of this region of danger, and as if to redeem and mitigate its perils, lies the harbor of Edgartown, offering good anchorage, always easy of access and perfectly sheltered. Situated at the junction of Muskeget Channel with Nantucket Sound, and but a short distance from the head of the Vineyard Sound, it may be said to be always *under the lee* for vessels approaching our shore from any direction. It has, furthermore, gained additional importance of late years because the bight of Mononey, known to seamen as the "Powder Hole," which formerly served as a refuge in easterly gales, has been wholly destroyed, as an anchorage, by an encroachment of sands not unlike that which now threatens the harbor for which we plead.

The accompanying letter, dated April 19, 1872, from C. B. Marchant, esq., the United States collector of customs at Edgartown, will give further information as to the commerce of this harbor and of its great value as a port of refuge.

CUSTOM-HOUSE, EDGARTOWN, MASSACHUSETTS,
Collector's Office, April 19, 1872.

SIR: I have the honor to give you below the tonnage of this customs district, with

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the number of coastwise vessels entered and cleared at the custom-house and the number of arrivals into the harbor of Edgartown from July 1, 1870, to June 30, 1871:

Tonnage	2,710.50
Entered, 26 vessels	Tons, 2,290.00
Clearances, coastwise, 23 vessels	Tons, 1,920.00

Vessels arrived, 2,700, (coastwise and foreign.) Duties collected, none.

Boats engaged constantly in fishing and relieving vessels in distress, 40; men employed, 80.

The tonnage of the district is principally employed in the Atlantic and Pacific whale-fishery.

The prevalence of dense fog during the late winter and early spring months bewilders masters of vessels from sea seeking an entrance into the Vineyard Sound, and these vessels, not unfrequently falling into the eastward of Gay Head, become entangled in the dangerous shoals of Muskeget, the channel through which into the Vineyard Sound, being tortuous and ever-changing because of the movable character of the bottom, frequently forces them into dangerous positions, and many wrecks is the result. Prompt assistance, with skillful pilots, has heretofore been rendered these vessels by the boats herein named, the south inlet affording a safe and convenient channel of communication at all times, but with the inlet closed assistance can only be rendered by a circuitous route around Cape Page, thus increasing the distance from this harbor to the point of danger some eight miles. Heretofore this harbor has been much more free from ice than during the last winter, the south inlet admitting a warmer current of water directly from the ocean, as well as increasing the force of the current through the inner harbor.

I am, sir, very respectfully, your obedient servant,

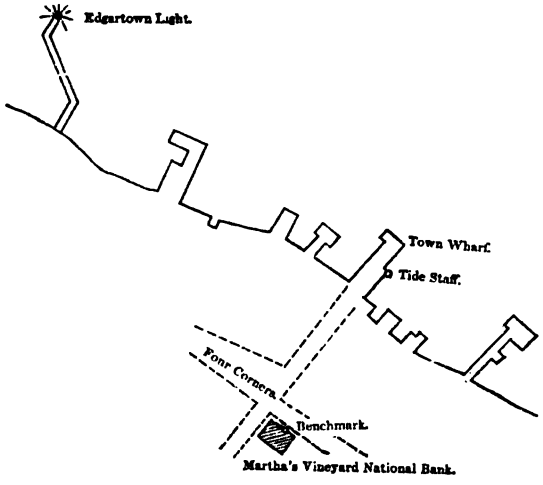
C. B. MARCHANT,
Collector.

General GEORGE THOM, U. S. A.,
United States Engineer, Portland, Maine.

UNITED STATES ENGINEER OFFICE,
Boston, Massachusetts, May 8, 1872.

GENERAL: I have the honor to forward to you a map illustrating the survey made in Edgartown Harbor, Massachusetts, in obedience to your written instructions of April 22, 1872.

The so-called Triangle Station, established by the United States Coast Survey last year, was identified, and from a point A, 26 feet north of the station, a line, A B, 4,200 feet long, was measured and staked off for every 100 feet. In every other of these points, viz, A, 2, 4,.....40, B, lines intersecting A B under right angles were laid out and marked by a set of signals along the high-water line, Aa, 2a,.....40a, Ba, and another set near the crest of the beach, Ab, 2$_b$, ...40$_b$, B$_b$, thus giving 22 ranges in which soundings were taken. Six signals, I,.....VI, were established on Cotamy Point, 2 and 2 forming a range intersecting the first-mentioned 22 parallel lines; the position of these 6 points was determined by sights from three stations in line A B. The soundings are all reduced to mean low water, which plane of reference was determined last year by the United States Coast Survey. The tide-staff is placed on the "Town Wharf," (see sketch,) and repeated levelings from the bench-mark, water-table of Martha's Vineyard, National Bank, over right hand of front steps, which is in Ref. 15, 16, gave mean low water on the staff + 2.40. The mean rise and fall of tide is 2.5 feet.

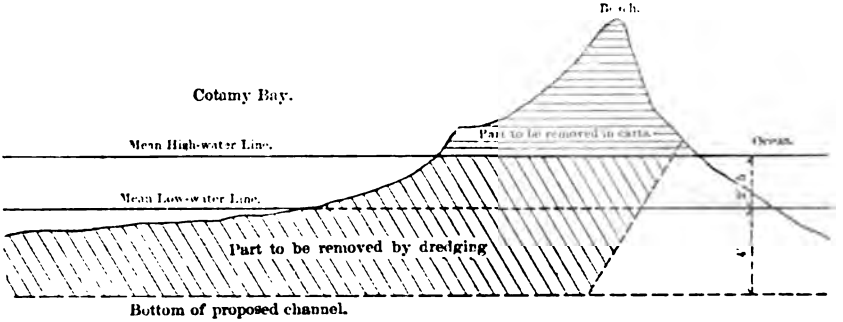


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A topographical survey of part of Cotamy Beach was made and cross-sections of the beach 200 feet apart leveled.

After the general features of the beach and the bottom were determined, the proposed channel was laid out thus: Crossing A B in three points, E, D, and C, respectively 1,520, 1,683.5, and 1,847 feet distant from A, three parallel lines, K H, J G, and I F, under an angle of 66° 30′ with A B, mark the easterly, the axis, and the westerly edge of a channel 300 feet wide, running from the natural channel east of Cotamy Point, through Cotamy Beach, to the ocean.

Additional soundings were made in these three lines, and the character of the bottom determined by borings. The bottom is very coarse sand, free from bowlders. Specimens of the sand are retained in this office.

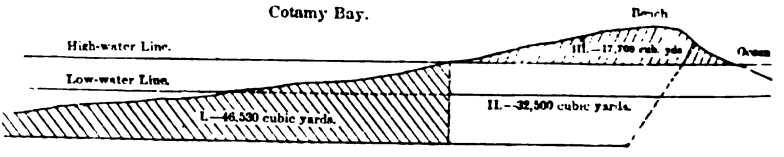


As shown in the sketch, the material from 4 feet below mean low water is to be excavated by dredging, after the beach above the high-water mark has been removed in carts or barrows.

Besides for the above-mentioned channel 300 feet wide, estimates have been made for channels 100 feet and 200 feet wide, having line I F as their westerly limit; also estimate for a channel 300 feet wide from Cotamy Point through the deep hole south of Cotamy Point, (see 4-foot curve.) This channel is indicated on the map in red dotted lines. The amounts of material to be excavated are specified in the following table:

Descriptions of channel, four feet deep at mean low water.	Length of axis from ocean to four-foot curve.	Material to be removed.	
		By dredging.	In carts.
	Feet.	*Cubic yards.*	*Cubic yards.*
Straight channel 300 feet wide, line I F the westerly limit	2,530	64,810	17,43[illegible]
Straight channel 200 feet wide, line I F the westerly limit	2,470	40,955	11,98[illegible]
Straight channel 100 feet wide, line I F the westerly limit	2,260	19,555	6,45[illegible]
Curved channel 300 feet wide	3,900	79,030	17,70[illegible]

The S-curved channel is in the main the same as proposed by Professor H. L. Whiting, United States Coast Survey, in his report on Edgartown Harbor of January 2, 1872. He states: "By following the general course of this old channel and removing such portions of the shoal as in places now block it up, a passage-way 300 feet wide and 4 feet deep may be obtained by the excavation of about 41,000 cubic yards of the material of the shoal." The amount of excavation stated in the table above for this channel is 79,030 cubic yards. As shown in diagram, the amount to be excavated of the shoal,



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I, is 46,530 cubic yards, and the amount to be excavated in the beach from the high-water level to 4 feet below mean low water, II, is 32,500 cubic yards, which makes a total of dredging 79,030 cubic yards, and explains the difference between the two estimates.

Allowing 10 per cent. increase for loosening of material of the amount to be excavated, and taking 50 cents per cubic yard as the cost of dredging, 30 cents per cubic yard as the cost of removing the beach above high water in carts or barrows, the cost of the four different channels will compare as follows:

I. Straight channel, 300 feet wide	71,300 cubic yards, at 50 cents, 19,200 cubic yards, at 30 cents,	$41,410
II. Straight channel, 200 feet wide	45,050 cubic yards, at 50 cents, 13,160 cubic yards, at 30 cents,	26,473
III. Straight channel, 100 feet wide	21,510 cubic yards, at 50 cents, 7,140 cubic yards, at 30 cents,	17,897
IV. S-curved channel, 300 feet wide	86,930 cubic yards, at 50 cents, 19,470 cubic yards, at 30 cents,	49,306

It is believed that a straight cut through the flats and the beach would very soon double its width and increase its depth to 10 feet at low water, owing to the peculiar flow of tide in Cotamy Bay and in the ocean outside the beach. For 7 hours the level of the water in Cotamy Bay is higher than in the ocean outside; this difference is nearly 2 feet during 4 hours. (See Professor H. Mitchell's tidal curves in his report on Edgartown Harbor.) A large portion of the water in Mattakeesett Bay will be drawn toward the opening in the beach and force its way to the ocean with considerable scouring power.

The fact that the previous openings in this beach have moved from west toward east would speak in favor of the S-curved channel, opening at the head of Mattakeesett Bay, instead of the straight channel 1,800 feet east of this; still, as the opening of 1856 has proved to move eastward at the rate of 10,000 feet in 15 years, it would only take 2¼ years for the former to reach the position of the proposed straight channel. The latter has the advantage, first, of being easier to navigate; second, its length is 1,370 feet less than the former; third, the crest of the beach here is 13 feet above high-water level and covered with beach-grass, whereas the beach at the head of the bay, for a distance of 2,000 feet, is clear sand, only 6 feet above high water, and washed over by high-storm tides; (line of dead sea-weed along the high part of the beach is Ref. 9, 14;) great quantities of sand are carried over the western part of the beach in every southerly storm, which is not the case at the proposed entrance; fourth, the cost will be 19 per cent. less.

In conclusion, I will state that the cost of a channel from the deep water to Cotamy Point, running in a direction south 31° 30′ west, having a width of 300 feet at the bottom and a depth of 4 feet at mean low water, will be—

Excavation by dredging 71,300 cubic yards, at 50 cents	$35,650
Removal of beach in carts, 19,200 cubic yards, at 30 cents	5,760
Total	41,410
Contingencies, about 9 per cent	3,590
Grand total	45,000

Very respectfully, your obedient servant,

SOPHUS HAAGENSEN,
Civil Engineer.

Brevet Brigadier-General GEORGE THOM,
Lieutenant-Colonel, Corps of Engineers.

APPENDIX W.

ANNUAL REPORT OF MAJOR H. M. ROBERT, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, August 26, 1872.

GENERAL: I have the honor respectfully to submit the following report of operations on the works of river improvement in my charge for the fiscal year ending June 30, 1872:

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W 1.

IMPROVEMENT OF THE WILLAMETTE RIVER AT PORTLAND, OREGON, AND TO MOUTH.

Swan Island Bar.—Work has been carried on at this bar for five years past, the object for the last three years being to cut a channel 100 feet wide and 17 feet deep at low water entirely across the bar, which is located two miles below the city of Portland, Oregon. The dredger used is loaned by the city authorities to the Government, and is of the Osgood class, and with it work can only be carried on for about five months in the year, as it cannot be used during the high stages of water, of which there are two every year, the one in the winter resulting from the rains and the one in the summer from the melting of the snows in the Cascade range of mountains.

This past year, after the usual repairs to the dredger, the work on Swan Island Bar was resumed on August 11, and continued until December 7, excepting for twenty-six days, during which the dredger was at the mouth of the river. The weather in the spring of 1872 was such as to cause serious apprehensions of being unable to do any work, but on March 27 the dredger went to work again, and continued until May 10, when the summer rise stopped all further work. The number of cubic yards excavated was, by scow measurement, 23,933. The distance advanced on the line of 17-foot cut was 1,120 feet.

Of the above amount excavated, 19,418 cubic yards were clay and gravel, forming the permanent bed of the river, and 4,515 cubic yards were part of a deposit in the channel resulting from the freshets, which had to be cleaned up on resuming work.

An examination of the bar this last spring showed the effect of the winter flood to have caused a remarkably large deposit, amounting to 7,000 cubic yards in the channel already cut, and 10,000 cubic yards above the cut and on its prolongation by the most economical line to the 17-foot curve. This new deposit above the cut varies in depth from 1 to 2 feet, removing the 17-foot curve about 700 feet farther up the river and placing it 1,150 feet above the point to which the cut was advanced at the cessation of work in May.

The deposit in the upper part of the cut was 4 feet deep, whereas at this point the excavation during the previous summer had been only 3 feet, thus raising the bar 1 foot above its level before the cut was made. The result of this one freshet alone will therefore add about 17,000 cubic yards of material to former estimates for the completion of this cut. From all I have been able to learn of this bar, it was supposed not to have altered for years. Finding such a great change in it, I had a survey of the river made from the bar to the city of Portland, but found that nothing had occurred within these limits to give trouble or to alter the plan of the improvement. The extensive grading recently done by the railroad company and the city authorities in East Portland, and the fact that the winter freshet was the highest that has been since 1862, would in part account for the great amount of the deposit.

During the next fiscal year the proposed operations are the thorough repair of the old dredger, which will have to be used during the entire year; the building of a new dredger of the Morris & Cumings' pattern, and two dumping-scows by the United States, for continued work on this river and the Columbia, (the old scows cannot be repaired, and they are liable to fall to pieces at any time,) and the continuation of the 17-foot cut at Swan Island Bar, which requires the excavation of 25,000

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cubic yards of material, and could be completed this fall if it were not for the bars at and near the mouth of the river, which will probably require attention.

This cut is now 3,250 feet long, and there are yet 1,150 feet of cut remaining to extend it to the 17-foot curve above the bar.

BAR AT THE MOUTH OF THE WILLAMETTE RIVER.—In September and October last the dredger and snag-puller were sent to this point, a steamer and two ships having grounded there, and the depth at extreme low water found to be but 12 feet for a distance of 300 feet; 3,325 cubic yards were removed on a line of 400 feet long in thirteen working days, the rest of the twenty-six days during which the dredger was absent from Swan Island being taken up by moving to and from the bar, breakage of machinery, and other causes of detention. The snag-puller, at the same time, removed forty trees and stumps from the channel, some of which had to be removed by the aid of a diver in armor, and by striking which the dipper and machinery of the dredger were much injured, so as to stop the work for six days.

Five trees on the end of Coon Island, and about 100 feet from the center of the channel, were cut down, as they were liable at any time to fall into the channel and obstruct it.

Examinations with the lead-line and sextant were made during the spring on this bar, and for a distance of three and a half miles up the river, extending over shoals reported as existing by the river pilots. The result shows a good deep channel, with the following exceptions: (1) For 500 feet on this bar, at the mouth of the Willamette, where the average depth is 15½ feet; (2) near Willamette Slough, where for 400 feet it shoals to 15 feet; and (3) 2,700 feet above it shoals again to 15 feet for a distance of 800 feet, the nearest line between the two curves of 17 feet being here at an angle of 45° with the shore. These three are the points where work will probably be necessary this fall, and there may be more trouble caused by the summer back-water from the Columbia River, especially at the mouth of the Willamette, where the back-current during the high-water season is very strong.

The operations proposed at this point during the next fiscal year are such dredging and snag-pulling as may from time to time be necessary to admit of the passage of the ocean-steamers.

During the year there were excavated on the Lower Willamette River 27,258 cubic yards of material at a cost, including the expense of repairs, (over $2,700,) of 47.65 cents per cubic yard. This is much lower than can be safely estimated for in future, being about one-half the cost for the previous two years, and is partially due to the fact that so much of the material was a fresh deposit, and therefore so easily removed.

During the fiscal year ending June 30, 1872, the following amounts were received and expended on account of the appropriation for the "improvement of the Willamette River at Portland, Oregon, and to mouth of river:"

Balance reported available July 1, 1871		$17,716 54
Balance in hands of Colonel Williamson July 1, 1871		253 66
Total available July 1, 1871		17,970 20
Expended during the year:		
Dredging	$12,990 30	
Snagging	562 10	
Surveys	563 00	
		14,115 40
Balance remaining on hand July 1, 1872		3,854 80

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Appropriated June 10, 1872, for improvement of the Lower Willamette River, Oregon	$50,000 00
Available July 1, 1872	53,854 [illegible]

Estimate for the fiscal year 1873–'74:	
Running expenses of the United States dredger to be constructed this season, seven months, at $2,500	$17,5[illegible]
Repairs and care of dredger and scows	1,5[illegible]
Examinations on the rivers	1,0[illegible]
	20,0[illegible]

which I would respectfully recommend to be appropriated so as to permit of this new dredger being used when necessary on the bars of the Lower Columbia River, as well as on the Lower Willamette. The object of these appropriations has been and is to enable large sea-going vessels to reach the city of Portland, Oregon; but by being limited to the Willamette River, though vessels should ground on the Columbia in sight of the dredger, no work could be done on the latter river. One bar in the Columbia last year was a more serious hinderance than anything in the Willamette. The difficulty would be removed by wording the appropriation thus: "For the improvement of the Willamette and Columbia Rivers from Portland, Oregon, to the sea."

W 2.

IMPROVEMENT OF THE WILLAMETTE RIVER ABOVE OREGON CITY, OREGON.

After a survey by Major Williamson, Corps of Engineers, and report thereon, dated December 23, 1870, Congress appropriated for the improvement of this river $16,000, which was available July 1, 1871.

A reconnaissance was made by myself in person in July, 1871, after which a project and estimates for the application of the appropriation were submitted and approved by the Chief of Engineers, and in accordance therewith a scraper, of the style known as Long's, and used on the Upper Mississippi River, was built and attached to a steamer hired from the People's Transportation Company. A snag-boat was also built by contract and furnished with every appliance without steam power, for the removal of the dangerous snags from the river-bed. The original project for doing the work of improvement combined the operations of these (the snag-boat and scraper) with the building of 1,[illegible] linear feet of wing-dam. However, as, after advertising, no bids were received for the wing-dams, and as the company which owned all the boats on the river, and was most deeply interested in its improvement—the People's Transportation Company—had just sold out to the same parties who owned the railroad running parallel with the river, I could make no arrangements whatever to construct the wing-dams during that low-water season.

The scraper attached to the steamer Success worked twelve days to considerable advantage, at Matheney and Yam Hill bars, while under my own supervision, but after I left her no more was done in ten days than had been done in two while I was on board. Being satisfied of the unfitness of the captain for the work, and new parties having obtained

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control of all the boats on the river, who were unwilling to make any bid for building the dams, I returned the boat to its owner and gave up all idea of doing anything that season except snagging.

The result of the scraping at Matheney's was such as to give a good channel to boats carrying 75 tons of freight, which, before the scraping, could not get over up stream empty without the aid of lines, cor carry more than 25 tons going down. It also rendered the use of wing-dams at this point unnecessary. Until the scraping, this was the worst bar on the portion of the river used in the summer season.

The snag-boat was manned and at work November 6, 1871, and was drawn off on the 28th of the same month by reason of a sudden rise of water. During this time she had moved 39 snags, aggregating, in estimated weight, 146 tons. Some of these snags were 120 feet long and some 15 feet in circumference.

The boat is 100 feet long, and well fitted for the work on the river. She has no steam-power, and has to be towed up stream, clearing up the snags as she drifts down. The cost, including her outfit, $4,857.56, and requires a crew of six or seven men.

After due advertisement, a contract was signed, May 1, 1872, for building the wing-dams in September and October next, for the sum of $2.50 per linear foot of dam.

The proposed operations during the year 1872–'73 are the removal of the most dangerous snags in the river during next August and September by the United States snag-boat Willamette, and the building of 2,100 feet more or less of wing-dam under the aforesaid contract with Joseph Paquet, in connection with the use of the Long's scraper, on the worst bars, for a few days in September.

The canal and locks now being built near Oregon City will, when completed, allow boats to pass from the Upper to the Lower Willamette, and it is thought that they will break up the monopoly of the river transportation and stimulate competition on the Upper Willamette. The State supplied $200,000 of the necessary funds, and the charter requires that they be completed by January 1, 1873. Until these locks are opened there can be no competition on the river. I do not think the amount of trade thereon in the summer sufficient to justify any great outlay on the part of the Government for its improvement. The removal of dangerous snags and a small amount of work on the bars in the way of scraping and wing-dams are all that seems justifiable after the completion of the work contemplated this season.

A full report of the operations of the past year was forwarded to the Chief of Engineers February 10, 1872, to which I respectfully refer for details of the work.

There have been received and expended on account of this appropriation during the fiscal year ending June 30, 1872, the following amounts:

Available July 1, 1871	$16,000 00
Expended during the year	7,746 39
Balance available July 1, 1872	8,253 61
Amount asked for the year 1873–'74	3,000 00

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W 3.

IMPROVEMENT OF THE UMPQUA RIVER, OREGON.

A reconnaissance was made by Major Williamson, Corps of Engineers, of the rapids of this river, (see report Chief of Engineers, 1871, page 909, and an appropriation made by Congress of $22,500, which was available July 1, 1871.

In July, 1871, I had an examination made by my assistant, Mr. Frank H. West, of that part of the river known as the cañon, and not reported on by Major Williamson. His report of this examination was forwarded to the Chief of Engineers with my letter of August 9, 1871.

On the 12th of August, after due advertisement, a contract was signed with W. B. Clarke, of Roseburg, Oregon, for the blasting of rocks in the various rapids, at $6.95, coin, per cubic yard. The work for the contractor, which was the removal of 1,888 cubic yards of rock at fifteen different points, was immediately laid out. The work was pressed with great vigor by the contractor and completed during the month of October. While inspecting the work with my assistant, we descended the Umpqua from Roseburg to Scottsburg in a small boat. During this trip, which took seven days, I noticed a number of detached rocks in the South Fork of the Umpqua, which would prove serious hindrances to navigation, even when the river was 5 feet above its low-water stage. These, amounting to 30 cubic yards, I had removed at $5 per cubic yard. A mill-dam at Kellogg's I also had cut through.

This completed all the work proposed that season, which was more than recommended by Major Williamson or asked for by the steamboat company navigating the river, and it remained to see the effect of the improvement on the channel after high water had set in before expending the balance of the appropriation.

The president of the Merchants and Farmers' Navigation Company having placed the steamer Enterprise at my disposal, to make an attempt to ascend the river with her, I went to Gardiner City, near the mouth of the Umpqua, in March, with the intention of making the attempt. Finding, on my arrival, however, that no suitable arrangements had been made for the trip, and that they could not then be made within a month, and that all the stockholders residing in Gardiner City protested against the order of the president of the company placing the boat at my disposal, and, more than all, that, from what I had seen already of the river, it would never pay to navigate it—finding all this, I abandoned the attempt, and on the 6th of April I forwarded to the Chief of Engineers a special report on the subject, to which I beg to refer for details of the work and a discussion of the whole subject, with my reasons for thinking that no improvement of this river should have been attempted.

There has been received and expended on account of the improvement of the Umpqua River, Oregon, during the fiscal year ending June 30, 1872, the following sums:

Available July 1, 1871	$22.500
Forfeited deposit of William Turnbull, bidder	111
Total available	22.611
Expended during the year	17.925
Balance turned into the Treasury May 9, 1872	4.686

No further appropriation recommended.

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CUSTOM-HOUSE, PORTLAND, OREGON,
August 30, 1872.

Imports and exports at the port of Portland, Oregon, during the fiscal year ended June 30, 1872, and also for the month of July, 1872. It will be borne in mind that those are statistics of direct foreign trade only.

Value of merchandise imported at the port of Portland during the year ended June 30, 1872.

July, 1871	$86,527	April, 1872	$24,642
August, 1871	70,882	May, 1872	26,097
September, 1871	70,882	June, 1872	
October, 1871	6,088		
November, 1871	25,312	Total	554,122
December, 1871	43,249	Imported July, 1872	108,046
January, 1872	101,315		
February, 1872	58,323	Total	662,168
March, 1872	30,042		

Value of exports (foreign) from the port of Portland.

July, 1871	$10,173	April, 1872	$27,761
August, 1871	25,585	May, 1872	14,201
September, 1871	37,110	June, 1872	12,167
October, 1871	127,947		
November, 1871	70,412	Total value for year	573,398
December, 1871	21,552	Exported July, 1872	60,930
January, 1872	53,984		
February, 1872	44,618	Total	634,328
March, 1872	128,288		

Duties collected on imports at the port of Portland during year ended June 30, 1872.

July, 1871	$41,013 92	April, 1872	$16,700 96
August, 1871	29,269 86	May, 1872	19,151 18
September, 1871	37,997 80	June, 1872	2,891 59
October, 1871	11,151 70		
November, 1871	15,485 53	Total	279,617 50
December, 1871	18,721 03	Duty collected July, 1872	40,148 43
January, 1872	41,109 75		
February, 1872	30,207 00	Total	319,765 93
March, 1872	15,917 18		

Vessels owned and documented in the District of Willamette are 57 in number. Aggregate tonnage, 15,727.73.

Number and tonnage of vessels which entered and cleared at the port of Portland, Oregon, during the fiscal year ended June 30, 1872.

	Coast trade.		Foreign trade.		Total.	
	Vessels.	Tons.	Vessels.	Tons.	Vessels.	Tons.
Entered	103	89,576	30	14,175	133	103,751
Cleared	117	95,130	40	21,077	157	116,207
Total entered and cleared					290	219,958

In addition to the above, at least 500,000 tons of shipping have entered and departed from this port in the coastwise trade which by law were not obliged to, and did not, enter at the custom-house.

H. W. SCOTT, *Collector.*

A true copy:

SAM'L O. S. SOTTOR,
Engineer Clerk.

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W 4.

SURVEY OF SAINT HELEN'S BAR, COLUMBIA RIVER, OREGON.

The ocean-steamers having experienced considerable trouble at this point on several occasions, a survey of the locality was recommended by me and approved of by the Chief of Engineers.

The survey was commenced in February, 1872, and continued at such intervals as my assistant could be spared from his other duties. Nearly 3,000 soundings were taken on the bar and its vicinity, and two and one-half miles of shore-line, on each side of the river, determined. Borings were also made to ascertain the nature of the material beneath the bed of the channel.

A full report, with copy of chart of the survey, was forwarded to the Chief of Engineers July 10, 1872.

About five weeks' dredging, to cut a channel carrying 18 feet at low water, and 130 feet wide, across the lower end of the bar, will be required. This will cost about $2,750.

Examinations will be made after the summer high water in the Columbia this year, and again at the close of the low-water season, to determine the changes on the bar, resulting from the effect of the high water and the summer tides.

There have been received and expended on this account during the fiscal year ending June 30, 1872, the following amounts:

Received for survey of Saint Helen's Bar, Columbia River	$5[illegible]
Expended during the year	4[illegible]
Balance on hand July 1, 1872	19 [illegible]
Estimate for fiscal year 1873–'74:	
Five weeks' dredging on the bar	$2,75[illegible]
Examination on the bar and river	2[illegible]
Total	3,00[illegible]

Instead of making this a separate appropriation it would be much better, however, as recommended under the head of the improvement of the Lower Willamette, to consider the rivers from Portland to the sea as but one river, which is to be improved wherever found necessary. Other bars may form that are more troublesome than this, and it is not well to limit the appropriations to single bars that are ever changing.

Herewith are transmitted commercial statistics of this district.

W 5.

SPECIAL REPORT ON THE IMPROVEMENT OF THE UMPQUA RIVER OREGON.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, April 6, 1872.

SIR: I have the honor to submit the following special report upon the improvement of the navigation of the Umpqua River, Oregon.

My last report, dated August 9, 1871, inclosed the report of my assistant, Mr. F. H. West, on his reconnaissance of the Cañon Rapids. Proposals for removing the obstructions were advertised for July 25, in

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papers in Portland, Eugene City, and Roseburg. The bids, an abstract of which is inclosed, marked A, were opened August 12, and the contract awarded to William Turnbull, at $6.73, coin, per yard, (cubic,) but he failing to sign the contract his deposit was declared forfeited, and the award made to W. B. Clarke at $6.95, coin, per cubic yard.

On the 23d of August I dispatched Mr. West to the Umpqua River to lay out and measure the work at all the rapids. This duty was completed by the 16th of September, but work on each rapid was commenced as soon as laid out.

By paying high wages a large force was obtained, to the detriment of the railroad-contractors, and the work was vigorously pressed simultaneously at all points.

On the 11th of October I set out with Mr. West to inspect the work and make a personal examination of the river from Roseburg to Scottsburg.

On the 13th we left Roseburg in a skiff, and arrived at Scottsburg on the 20th. As we lay over on Sunday, we were actually only seven days descending the river.

After the descent I was no longer surprised at our inability to learn of any one who had ever been all the way down the river in low water. The stream seemed to be a succession of rapids, with dead water between. Occasionally, instead of a rapid, would be a vertical fall. To me it seemed impossible for a steamboat to ascend the river, even if the water were 4 or 5 feet higher. Still, a boat *had* gone from Scottsburg to Roseburg, and it seemed to be the prevailing opinion among the people that it could be made to pay to navigate the river.

I found that, with two exceptions, all the work laid out had been performed, and these places were soon after worked to my satisfaction. I found several detached rocks in the South Fork of the Umpqua, and some rocks above Crow's Rapids, which it seemed necessary to remove, as also an old mill-dam, at "Kellogg's," through which had to be made a cut of 50 feet. I made arrangements to have this work done immediately. There were many other places where I thought work would be needed, but as more had been done than was recommended by Colonel Williamson, or asked for by Captain Horn, who commanded the Swan when she went up the river, and as the Merchants and Farmers' Navigation Company, organized on purpose to navigate the Umpqua, thought nothing further was necessary, I concluded to do nothing until I had an opportunity of seeing the river in its navigable state.

The secretary of the Merchants and Farmers' Navigation Company, who had been employed by the contractor to superintend the work, thought there would be no trouble in navigating the river with 5 feet of water.

Not hearing anything from the company after the high water had set in, I wrote to inquire, and found that the steamer Enterprise had failed in an attempt to pass the first rapid, Sawyer's, about twelve miles above Scottsburg, but that if I wanted to make the trial, the steamer was at my service. I immediately accepted the offer, and left here March 4 for Scottsburg, where I arrived on the 12th, having lost three or four days, after reaching the Umpqua, in order to communicate with the directors of the company, after learning that no preparation had been made for the trip. As the agent of the company was in Gardiner, I had to go there, and soon learned that all the stockholders on the lower river were opposed to the expense and risk of the attempt to take the boat to Roseburg. At a meeting of these stockholders the matter was discussed, resulting in their all signing a protest against the president's

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order placing the boat at my disposal. As the boat itself could not be placed in a condition for the attempt in less than six weeks or two months, at an expense of over $800, it was necessary to abandon the attempt.

The correspondence which explains this is inclosed, marked B, C.

During the trip I examined Mills's and Sawyer's Rapids as well as I could from the land, and I think that all the work was done that was necessary to carry out the plan.

The theory of the improvement of the Umpqua River was simply to provide a sufficiently straight channel, not less than 30 feet wide, the bottom of which should not be above the level of extreme low water. The obstructions to be removed were rocks upon which a boat might strike. The removal of these rocks, where it had any effect upon the rapidity of the current, would generally increase it. This project has been carried out in the case of sixteen rapids, and several dangerous isolated rocks have been removed. Not a single rock was left that had been reported as troublesome.

Yet after all this, in my judgment, this river can never be *profitably* navigated on account of the rapidity of the current. From Roseburg to Scottsburg, by the wagon-road, is fifty miles, and the cost of hauling will average about 1 cent per pound; and thence eighteen miles to Gardiner, by steamer, at $4 per ton. (All prices given in this report are in coin.) To compete with this, the freight by steamer from Gardiner to Roseburg was put at $15 per ton measurement, which the agent informed me was the highest price they could get, and over 1 cent per pound. On their trial-trip they took fifty tons at this price. If they charged higher than this they could get no freight. Supposing there were no competitors but the wagon-road, the first question to be decided is whether, after a channel is opened through the rapids, it would pay a company to transport freight on the river at $15 per ton. As the reconnaissance and appropriation had been made before the work was transferred to me, and I was merely required to submit a project for its expenditure, I did not think I had anything to do then with the investigation of the question of the advisability of the improvement, especially as to have done so at that time would have postponed the work until after high water, or for a period of one year. In reviewing the work, however, and making a report thereon, its success or non-success must be considered, and a careful investigation of the subject satisfies me that the appropriation should never have been made. The channel is made, but it will not pay any one to navigate the river. When the Swan was taken up I understand she had a crew of twenty volunteers, and she made the trip in six actual running days, though the trip occupied twelve days, I believe. She went up when the water was just right, and had to be "lined up" over twenty rapids. Since the channel has been cleared there has been no reduction in the current or the amount of work necessary to haul the boat over the rapids with lines. The only improvement is in diminishing the danger of striking rocks and in giving a channel in any stage of the water when it is greater than 5 or 6 feet above low water. The Swan was a small boat, 100 feet long, drawing, when light, 20 inches of water. The new steamer Enterprise is 20 feet longer, has 4 feet more beam, and draws 6 inches more water; but by using proper machinery I think 20 men would be sufficient for crew, the great point being to have enough men to handle the ropes. Supposing that the round trip could be made every ten days, the running expense would not be less than $1,000. Allowing $500 per round trip for insurance and repairs, an amount much less than I found

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any one willing to guarantee them for, and we have a total expense of $1,500 per trip. Giving an average of 50 tons each way, at $15 per ton, the freight per round trip would amount to $1,500, leaving no margin for contingencies or profit. I think this statement of the case as favorable to the steamboat company as facts will justify, and that the company could not reasonably expect to do more than cover all expenses and risk, without making any profit, and that five or six months in the year is a liberal estimate for the time that the river is sufficiently high for navigation.

The above is all calculated upon the supposition that the river has only to compete with the wagon-road from Roseburg to Scottsburg. But it has a much more formidable competitor in the Oregon and California Railroad passing through the very heart of Douglas County, and within one mile of both Oakland and Roseburg. This road is now graded as far as Oakland, and this summer it will be in running order from Portland to Roseburg, a distance of about two hundred miles. The freight tariff between these points, estimated from the published rates as far as the road is completed, will vary from about one-half cent per pound for grain to one cent per pound for first-class merchandise. This is less than the cost from Roseburg to Gardiner, which cannot be taken at less than one cent per pound. Supposing the cost of freight in the two cases to be the same, and that there would be no heavy insurance in shipping by the Umpqua River, there is still no question as to which port would have the preference.

The merchant leaving Roseburg could be in Portland in twelve hours, purchase and ship his goods, and the third day can have them in his store. So produce can be shipped to Portland in twenty-four hours, and there be shipped direct to Liverpool. Even if the object was to reach San Francisco, it could be done more cheaply and rapidly by way of Portland. From Gardiner to San Francisco, the freights are as high as from Portland to San Francisco. During the summer one of the coast-steamers stops every month at Gardiner, but at that season the Umpqua River cannot be used. Between Portland and San Francisco is a line of weekly steamers requiring but three or four days for the trip. In my judgment a Roseburg merchant who made his purchases in San Francisco, and shipped produce there, would find it to his interest to ship through Portland even if a company ran a steamer on the Umpqua. But I think the majority would do their business with Portland rather than with San Francisco.

The above reasons would, in case nothing had been done to the river, prevent my recommending the expenditure of any money upon it. Now that the entire project has been carried out, and there has been a favorable winter, and no serious attempt made to navigate the river, I would most certainly recommend that no further expenditures upon it be made. When I say no serious attempt to navigate the river has been made, I do not underrate the efforts made by the officers and crew of the Enterprise to get her over Sawyer's Rapid in January last. The channel was there, but the current was so rapid that, with the full power of her machinery exerted, the strain on the line was so great that it was in danger of breaking every minute. The crew should have been doubled, her capstan tripled in power, and her lines in number, before thinking of making the attempt. The objection of the company to doing this is that it will not pay. If it does not pay to navigate the river now, before the railroad comes into competition, it certainly will not afterward. Additional removal of obstructions will not reduce the current, and that is all which now hinders its navigation.

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A.

Abstract of bids for removal of obstructions in the Umpqua River, Oregon, opened August 12, 1871.

No.	Name of bidder.	Bid per cubic yard
1	Wm. Turnbull	
2	W. B. Clarke	
3	J. D. Van Buren and D. C. McClellan	
4	Jas. Walton	
5	C. M. Cartwright	
6	R. H. Lord	

Nature of work—partly submerged rock.

E.

Abstract of quantities of rock removed on the Umpqua River, during the months of September and October, 1871.

No. on drawing.	Location.	Cubic yards removed
No survey.	Detached rocks between Roseburg and head of Crow's Rapid	
1 and 2	Crow's Rapid	
3	Cañon obstruction, No. 1	
4	Cañon obstruction, No. 2	
5	Cañon obstruction, No. 3	
No survey.	Cañon obstruction, No. 4, detached rocks	
6	Cañon obstruction, No. 5, Upper Clayton Rapid	
7	Cañon obstruction, No. 6, Lower Clayton Rapid	
8	Cañon obstruction, No. 7	
9	Cañon obstruction, No. 8	
10	Cañon obstruction, No. 9	
11	Upper Deloney Rapid	
12	Middle Deloney Rapid	
13	Lower Deloney Rapid	
14	Mills' Rapid	
15	Hart's Rapid	
16	Sawyer's Rapid	
	Total	

Of which 1,888 yards were removed under contract at $6.95, coin, per yard, and the balance [illegible] for $150, by verbal agreement.

W 6.

SURVEY OF SAINT HELEN'S BAR, COLUMBIA RIVER.

UNITED STATES ENGINEER OFFICE.
Portland, Oregon, July 10, 1872.

SIR: I have the honor to submit herewith an extract from the report of my assistant on the survey of Saint Helen's Bar, Columbia River, together with a tracing of the chart of the survey.

This work was authorized by communication from your office, dated November 17, 1871, and was carried on, during the past spring, at such times as my assistant could spare from his other duties. The total cost of the survey has been $480.38, leaving a balance in my hands of $19.62, of the $500 estimated for, and allotted from the appropriation for "surveys and examinations on north and northwestern lakes and rivers."

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The present flood in the Columbia River will most probably change the bar to a greater or less extent, and necessitate a re-examination of its lower end, immediately before dredging. Before the close of the next low-water season another examination of the channel should be made, to ascertain the effect upon the channel by the summer tides. If the flood-tides do not tend to close the channel, then, when opened, it will remain so during that low-water season. But I think the June freshet will close it the next year. The effect of this freshet will be seen when the summer resurvey is made. It is probable that there will, from this cause, be much more dredging than shown on the chart herewith forwarded, and my estimate is made accordingly.

I would, therefore, recommend that a channel be cut, by dredging, 150 feet wide across the lower end of the bar, to a depth of 18 feet at low water, accompanied by the above examinations of that particular point. This will require about six weeks' work, and will cost $3,000, which I recommend may be applied thereto.

The appropriation already made for the improvement of the Lower Willamette will be sufficient to cover the above; but in case that appropriation cannot be legally applied to this work, I would recommend that the same be done with any funds that may be applicable thereto.

Extract from report on survey of Saint Helen's Bar, Columbia River, Oregon.

PORTLAND, OREGON, *May* 30, 1872.

Major H. M. ROBERT, *United States Engineer, &c.:*

* * * * * * *

Preparations for the survey were commenced February 1, the weather at that time, after a long continuance of rain and snow during the months of December and January, giving promise of a clear spell; the river being 3 feet above the low stage and falling. During the night of the 7th of February the weather turned warm and commenced to rain, and it continued stormy during the remainder of the month, raining hard, with strong southeast winds, causing a strong current from floods in the Willamette, Lewis, and other tributaries.

I had the necessary signals put up on both shores, extending from Lewis River on the upper, to Columbia City on the lower end, a distance of about two and one-half miles; also a good line for a base cleared away a little above the town; this was carefully measured, and found to be 2,194 feet 6 inches between stations. I established a gauge on the front of the steamboat-wharf; the zero, or low-water base was fixed upon after a careful comparison of the opinions of several of the oldest residents. A very satisfactory verification of this point was afforded during the survey. Meeting Mr. Caples on his wharf at the upper end of Columbia City, I asked him if he had any way of knowing how high the water was above the lowest stage; he said he could easily tell, and then measured the depth in the middle of the front of the wharf, which he stated he had only seen bare a few times. The depth measured was found to be 4 feet 6 inches. As this was my reduction at that hour, I felt satisfied my base was not far wrong. Since the completion of the map, I submitted it to the inspection of Captain Brown, one of the most experienced river-pilots. After a careful examination he expressed himself satisfied, from the general character of soundings in places not subject to change, that the reduction for low water was as near right as could be obtained.

The survey was carried on, as the weather would permit, in the following manner: the shore-line was determined by intersections on stations marking the most prominent points and line of shore, generally not less than three intersections taken on each station; these points were immediately located on return to camp, and verified in various ways as opportunity occurred. The intermediate line of shore was sketched in by passing from point to point in the boat. I was then prepared for the hydrography, which was done by the same method as is usual on the Coast Survey, viz, soundings taken at regular intervals, on lines from point to point; the alignment secured by good ranges, and all important changes in depth or direction determined by measurement of two or more angles between well-located stations, with a sextant. In measurement of depths, a lead-line was used, marked every 2 feet up to 5 fathoms; beyond that to half fathoms, frequent examinations being made to correct errors, which often occur from different causes. Although this part of the work was done at various stages of water, from 4 to 10 feet above low-water base, with a strong current and fresh southeast winds most of the time, when reduced it indicated a much greater de-

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gree of accuracy than I had expected. Soundings, when taken in a strong current are liable to much error from the difficulty of getting a perpendicular reading; I was, therefore, gratified to find the depths taken when the reduction was 9 feet, and a combination of unfavorable circumstances gave the same results as those when the river was 5 feet lower, with more favorable weather.

Having ascertained the nature and extent of the bar, and the points at which it might be desirable to dredge, it became necessary to find out if there existed any difficulty to this mode of deepening the channel; this was done by boring. I employed for this purpose a pole, on the end of which were screwed 10 feet of 1-inch gas-pipe, which were attached 6 feet of half-inch round iron, steel-pointed. The position of the boat being determined, it was allowed to drift down channel, the rod being held over the stern by one man, while the other managed the boat, and kept her in a given line. The pole was kept constantly dragging the bottom every few feet, it being forced into the sand from 1 to 2 feet. Having crossed the bar in this manner into deep water, the boat was then pulled up stream and allowed to drift down on another line; this was calculated to show the presence, if any, of rock within range. The rod being constantly kept on the bottom, rendered it almost impossible for a ridge to escape notice. Another precaution was taken to anchor the boat along a line at distances from 25 to 50 feet, and by the united efforts of both men drive the rod as deep into the sand as possible, which was from 4 to 7 feet, according to the depth of water, the pole measuring 33 feet in all. This method of boring in a strong current required some skill to prevent breaking the pipe off, which occurred several times. The limits of this work extended from the 5-foot curve, down past the lower buoy, and from the rocky bottom on the east to deep water in the Willamette Slough Channel for the lower section, and along the line indicated on the map by close sounding about 700 feet below the end of Sauvie's Island for the upper. As this examination occupied the greater part of four days, without showing any indication of rock other than on the map, I feel confident that every reasonable precaution has been taken to ascertain its presence in such places as may be recommended for improvement. In this connection it may be proper to state that the subject of currents, which must take the first place in any discussion having in view the permanent improvement of this bar, I have had but little opportunity to investigate, and as their probable influence will be shown under another head, I will merely state here that in addition to the regular ebb and flow of the tidal wave, the Columbia is subject to two freshets each year from entirely different causes. That which occurs during the winter is due to the rains which swell its tributaries on this side of the Cascade Range, causing the Lower Columbia to rise from 4 to 12 feet, lasting seldom more than a few days at its highest. What is known as the June rise commences about the 10th of May and lasts until the middle of July or 1st of August. This rise is dependent on the melting of snow east of the Cascades, and varies in height at Saint Helen's from 15 to 25 feet above low water, running with a velocity of not less than five miles an hour, from a month to six weeks. When the spring opens early the waters, or rain snows, run off gradually, and the river does not attain so great a height; the reverse brings unusually high water.

Saint Helen's, from which the bar derives its name, is a small town on the Oregon shore, about twenty miles below the mouth of the Willamette, and half a mile below the lower end of Sauvie's Island; in turn derives its name from Mount Saint Helen's, whose snow-capped peak there is a fine view,) is the county-seat of Columbia County, and at an early day was expected, under the fostering care of the Pacific Mail Steamship Company, who had extensive wharves and store-houses, to supplant Portland as the head of ocean navigation. This project having failed from want of a good back country, the rough and rocky nature of its immediate location, and the difficulty of getting water in the dry seasons, being built on a bench of solid rock, covered with only a few feet of soil, have caused it to fall into decay; it has, however, a fine lumber-mill and good fishing interest, which, with the fact of its being the county-seat, are now its principal supports. On the opposite side of the river the land is low and subject to overflow. Columbia City is a small village springing up about two miles below. By reference to the accompanying map it will be seen that a four-fathom channel exists in front of Saint Helen's, separated from the main Columbia channel by a sand flat; this is the outlet to the Willamette Slough, which is about twenty-five miles long, opening about three miles above the mouth of the Willamette, and is sometimes called its lower mouth, has an average width of from 400 to 500 feet, with some very short bends, and divides Sauvie's Island from the main-land. In the fall of 1866 I made a reconnoissance of this slough under the direction of Colonel R. S. Williamson, of the Engineer Corps, with the view of testing the practicability of making it the main channel, if it could be done at a reasonable cost. Three important advantages would be gained: First, the bar at the mouth of the Willamette; and, secondly, Willow Bar, in Columbia, would be avoided; it has good water, but some peculiarity of current in the vicinity causes large bodies of ice, floating down from the Upper Columbia, to gorge and effectually block up the river for weeks during winter, when otherwise navigation would be open. The waters of the Willamette, being much warmer than those of the

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Columbia, enable the river-boats to make regular trips at times when the latter river is entirely closed above Saint Helen's. Again, by passing down through this slough the bar at this point would be left on the right. (I will here state, before leaving this subject, that the principal difficulty in the way of carrying out this project is the presence of a ledge of rock about one and one-fourth miles above the town at the mouth of Milton Creek; there are also several places that would require dredging to get an 18-foot channel. The ledge alluded to runs entirely across the slough in a northeast and southwest direction, passing under the island, and crops out again in the Columbia River. I am under the impression the rocky point at Cunningham's is a cropping of this ledge.) By reference to the accompanying survey it will be seen that this bar consists of a sand-flat, tailing down from the lower end of Sauvie's Island about one and three-quarter miles, until it connects with the 15-foot curve on the Washington side of the main channel, forming an angle of about 20° with the line of rocky bottom running northwest and southeast; this is doubtless a part of the ledge on which Saint Helen's is built, and runs parallel to the one mentioned as existing above; the river has in fact worn itself a channel through the solid rock. For a mile below the island the flat varies in width from 700 to 1,400 feet, with from 6 to 15 feet water, the 18-foot curves east and west conforming very nearly with their respective shores; they then converge, the east bearing to the westward, while the west continues its generally straight course, forming a considerable angle with the line of shore, until at a point less than half a mile above the point of contact with the rock, where the distance between the curves is less than 300 feet. Near this place its eastern curve becomes irregular, bending round to the north and east until it joins the 18-foot curve on the rocky side, thus completely closing the channel to vessels drawing over 16 feet. The west curve, touching the rocky bend, forms its limit on the Oregon side. Near this point two entirely distinct channels meet, and form one main channel; these are the Columbia River and Willamette Slough. Previous to the year 1867 vessels and steamers of light draught were accustomed to cross this bar about half a mile below Sauvie's Island. There was then, as far as I can learn, a swag of about 13 feet at low water, which has now disappeared, having been kept open probably by the constant passage of vessels over it. In the spring of 1867, the Ajax, a steamer belonging to the North Pacific Transportation Company, from San Francisco, commenced to run. As she drew, when loaded, 18 feet, Captain Brown, the river-pilot, sounded out the present channel, and took such ranges as enabled him to run it, carrying over the bar 18 feet, as I was informed by him. For two years this steamer, during low-water stage, was accustomed to leave Portland half loaded and anchor in the Columbia at the mouth of the Willamette, when she would complete her cargo by means of lighters. The same is true of several deep-draught vessels which sailed from this port about the same time for Europe. Since the year 1869 this bar seems to have been gradually shoaling, last fall there being scant 15 feet on the deepest part. Its position and the character of the surrounding country render it difficult to cross, particularly at night. Pilots, knowing the proximity of rock, approach with great caution. During the time occupied by me on the survey, I remarked the rise and fall of the tides varied from —— to ——, although the current was running down stream on the surface at the rate of from two to four miles an hour. The usual rise and fall at the lowest stage of water is about 2½ feet. Of the direction of this ebb and flow I have no knowledge except what I infer from the character of the curves and the light of experience in such matters. During the seasons of flood, the direction and force of the currents are so varied by the different stages of water that I shall only mention them in a general manner. I also observed at Saint Helen's that the waters of each channel seemed to follow their respective shores in parallel lines, with somewhat accelerated velocity within the 18-foot curves. The main body of the Columbia water is deflected from Cunningham's Point to the Washington shore, striking below the mouth of Lewis River, causing annually a great abrasion of the bank, which is alluvial, also setting in motion large bodies of sand brought down by the latter river.

We see on the Washington or concave shore a deep scour, which is only stopped by the presence of solid rock; we also see two columns of water, influenced by different cross-sections, converging; the natural result is the formation of a bar at the lower end of Sauvie's Island. Let us suppose the slough closed, then we would have the scour of the Columbia only, which would doubtless soon make for itself a deep channel by following the line of rock, strike across to the Oregon shore above Columbia City, thence follow out in the present main channel. Again, suppose the slough-channel to remain, and take away the rocky flat, the Columbia would undoubtedly open for itself a good channel on the Washington side; the present sands might continue farther down, but soon the heavier column of water would gain the ascendency.

The survey shows that the Columbia tries to cut its way into the main channel across the lower end of the spit, and during the season of freshet I am inclined to think there is more water after making the necessary reduction to base of work than at the low stage. As the Washington shore wears away year after year, widening the cross-section, its power to scour at this point will become weaker and weaker, the bar conse-

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quently shoaler. This theory is, I think, substantiated by facts brought forth in regard to the changes which have taken place during the past few years. We have now stated the actual and probable effects of the winter and summer freshets, but as at a low stage, when the ebb and flood tides have their full effect, we experience the greatest difficulty, it is proper we should also consider their influence. The ebb and flow occur twice in twenty-four hours, having a rise and fall of 2½ feet, with a probable velocity of from two to two and a half miles an hour. The flood coming in from the sea would naturally follow up the main channel, being deflected by the rocky flat to the Oregon shore, thence follow up through the slough, a portion flowing over the rock. What then, can we expect but that the main body of water cutting away on the concave would deposit on the opposite, while that part flowing over the rock would of course cause it to fill above exactly as we have it? The fact of the bar lying under the lee of the rock prevents the flood passing up the Columbia Channel from exerting any scouring influence until past the point where most needed. Thus we have almost all the circumstances favorable to the formation and maintenance of a bar to contend against in forming a project for its improvement. Although at first sight the obstruction appears insignificant, and might be easily removed by scraping or dredging, after careful study I am convinced no permanent good can be effected by either method. I think it will be necessary to construct a line of wall by means of crib-work, piling, or throwing in loose rock, as circumstances may suggest after a more careful examination. The work must be done at some point which will deflect the main body of the flood into the Columbia Channel, thereby causing a scour on the bar at its narrowest point as indicated on the map.

Before any definite project can be recommended for its improvement it will be necessary to investigate the tidal currents, which cannot be done before the middle of August. In conclusion, I will state that the reason I have not attempted to indicate in the usual manner on the map the direction and force of currents is, as I have previously stated, during a freshet the currents are liable to vary in their force and direction with every few feet of rise and fall; the regular ebb and flow, however, of the tidal currents should be carefully examined and noted, as the entire success, in my opinion, having in view the improvement of Saint Helen's Bar, depends upon their proper guidance.

Respectfully, your obedient servant,

FRANK H. WEST, *Assistant.*

W. 7.

IMPROVEMENT OF UPPER COLUMBIA RIVER.

UNITED STATES ENGINEER OFFICE.
Portland, Oregon, January 2, 1872.

GENERAL: I have the honor to inclose herewith a communication from Captain J. C. Ainsworth, president Oregon Steam Navigation Company, in regard to the improvement of the Upper Columbia River.

At the request of Captain Ainsworth I took a trip up the Columbia to Wallula to get some idea of the nature of the rapids from personal observation, and wrote to Major R. S. Williamson, requesting the drawings made to accompany his report of the survey of the Upper Columbia Rapids. Copies of parts of these drawings, showing the rocks I would propose to remove, and an estimate of the cost, are appended hereto.

The cost is very great, being $39,294.44 for the removal of 1,200 cubic yards of rock, or an average of $32.74 per cubic yard. There would be probably on hand at the close of the work property costing $10,000 available for future improvements, which, if deducted, would make the net cost $24.40 per cubic yard, at which rate all additional work could be done.

The rocks I would propose to remove to the depth of 7 feet below low-water mark are as follows:

1. *John Day's Rock.*—This is an immense and dangerous rock in the middle of the channel at John Day's Rapid, having an area of 1,16

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square yards in the horizontal section, 7 feet below low water, and decreasing to an area of 51 square yards in the section at 2 feet below low water. The rock above the 7-foot section measures 960 cubic yards, giving an average depth of 2½ feet, but about one-half of the entire amount is contained between the 5 and 7 foot curves, averaging only 1 foot deep.

This increases greatly the expense of the work. Allowing that by drilling 2 feet below the required level, there will be required only one drill-hole for each superficial yard, then we would have 1,165 drill-holes, averaging 4½ feet deep, or a total of over 5,000 feet of drilling. The current is very rapid, from seven to ten miles per hour, according to Captain Heuer, and the water would probably, during the working season, be 3 feet above extreme low water. My plan of doing the work would be to construct a scow, and take advantage of the rapid current by using water-wheels to work the drills, these drills, ten in number, working in a well in the middle of the scow. As the scow, while floating in the water, probably could not be kept sufficiently steady for drilling, it would be lifted up by means of eight spuds, upon which the machine would rest.

I have had drawings of the machine made, and I think the work can be done in this manner more economically than by hand. The extra expense, above that of the scow, of $2,000, would be compensated for by saving 1,200 days of labor, costing $3,600, and much time wasted consequent on hand-drilling in such a place as this. The time occupied would be probably four months from the commencement of work at the rapids.

2. *The Devil's Bend.*—In Captain Heuer's report, (see page 882 report of the Chief of Engineers for 1868, appendix,) he mentions twenty-one rocks, aggregating 672 cubic yards, as forming the obstructions here. Of these I would propose to remove the following eleven, viz: A, containing 37 cubic yards; C, containing 3 cubic yards; E, containing 29 cubic yards; G, containing 35 cubic yards; H, containing 35 cubic yards; I, containing 15 cubic yards; M, containing 2 cubic yards; N, containing 14 cubic yards; P, containing .7 cubic yards; T, containing 1 cubic yard; V, containing 9 cubic yards; total, 180.7 cubic yards.

This would give an excellent channel, as will be seen from the accompanying map. The large rocks would require to be blasted, and, as the water is shallow, all large pieces, as well as the small rocks above mentioned, would be removed, by means of scows and grappling-irons, entirely out of the channel.

3. *Umatilla Rapids.*—These rapids, as Captain Heuer well says, require more work than all the rest included in his survey. He estimates the amount of rock to be removed at 2,512 cubic yards, costing $28 per yard, or a total of $70,000. It does not seem to me that any such thorough improvement as this is justifiable, at least at present. I am not prepared to submit any project for this improvement, but would propose, in connection with the work at Devil's Bend, only seven miles distant, to remove the rocks C, 14 cubic yards; D, 3 cubic yards; E, 21 cubic yards; and F, 17 cubic yards; a total of 55 cubic yards; which, according to Captain Ainsworth, are the worst rocks in the rapids.

The accompanying letter of Captain Ainsworth will show the importance of the work. If the Chief of Engineers sees fit to recommend an appropriation for this improvement, I would recommend that $40,000 be asked for the purpose.

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Herewith are transmitted four inclosures relating to this subject, viz:

1. Letter of J. C. Ainsworth.
2. Estimates of cost.
3. Sheets of tracings.
4. Inclosures.

OFFICE OF THE OREGON STEAM NAVIGATION COMPANY,
Portland, Oregon, November 23, 1871.

DEAR SIR: A survey of the Upper Columbia River was ordered several years ago, and, I believe, was accomplished under the direction of Colonel Williamson, of your department.

Senator Corbett informs me that no estimate of cost has ever been reported to the Chief of Engineers, and consequently no appropriation has ever been made for the work.

You could not but have been impressed with the great importance of the proposed improvement to navigation on the Upper Columbia River during your recent trip to Wallula. Walla-Walla Valley alone, with boundaries and resources sufficient for a State, to say nothing of Eastern Oregon, Northern Idaho, and Western Montana, is wholly dependent on the Columbia River for the transportation of the large surplus of grain (increasing so rapidly every year as to assume even now huge proportions) to the markets of the world. At present, wheat is worth 60 cents per bushel in Walla-Walla Valley. In Portland it is worth from $1.25 to $1.50 per bushel. The expense of freight from Wallula to Portland is 17½ cents per bushel, but the amount that is transported during the season of low water is so small as to make the great difference in prices above stated. If one rock in "John Day's Rapids" were removed, a few loose bowlders in "Devil's Bend," and one patch on "Umatilla Rapids," above the "Gravel Bar," we could then run our large-sized steamers, and, by the assurance of transportation, and consequently good markets, this large, important, and rapidly improving country would have free communication with, and access to, the commerce of the world. Every available house in Wallula is now filled with wheat that will have to remain there till next May.

You are aware that the Upper Columbia River is entirely destitute of timber; consequently all the fuel used by steamers on the Upper Columbia has to be transported a long distance at great cost, so much so as to preclude the multiplication of small steamers in sufficient numbers to do the business.

As briefly as possible I have presented the importance of this public work. Can you submit an estimate of cost to the Chief of Engineers, or can you in any way bring the subject before him, so as to insure favorable action on this very important subject?

Very respectfully, &c.,

J. C. AINSWORTH.
President Oregon Steam Navigation Company.

Major ROBERT, *United States Engineers.*

APPENDIX X.

REPORT OF THE BOARD OF ENGINEERS, PACIFIC COAST, UPON THE EXAMINATION OF SAN DIEGO HARBOR, CALIFORNIA.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., July 3, 1871.

COLONEL: In your letter of the 25th of April last, forwarding to this office the results of observations of currents at San Diego Harbor, California, you call attention to the fact that the upper portion of the harbor is rapidly filling up, and give your views as to the causes producing this result.

You are requested to ascertain by observation, during periods of flood in the San Diego River, and minor streams emptying at the head of the harbor, whether the process of deposition you mention actually

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takes place, and report the facts in the case, with any remarks and suggestions you may find expedient.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

THOS. LINCOLN CASEY,
Major of Engineers.

Lieutenant-Colonel B. S. ALEXANDER,
Corps of Engineers, San Francisco, California.

OFFICE BOARD OF ENGINEERS FOR THE PACIFIC COAST,
San Francisco, California, May 17, 1872.

GENERAL: In compliance with the instructions of the Department of July 3, 1871, I directed Captain Handbury, of the Corps of Engineers, "to proceed to San Diego, California, and make such observations as may be necessary to determine to what extent the harbor at that place is filling up, and the cause of the same." A copy of my letter of instructions to Captain Handbury is herewith inclosed.

In compliance with these instructions, Captain Handbury left this city on the 26th of January last, and made a survey of the southern portion of San Diego Harbor, and also an instrumental examination of the ground in the vicinity of Old San Diego, with a view of ascertaining the most feasible route for diverting the San Diego River from San Diego Harbor into False Bay.

Since his return to this city, Captain Handbury has reduced his soundings and prepared a hydrographic map of the southern portion of San Diego Harbor, showing the changes which have taken place in this part of the harbor since 1856. He has also prepared a plan for the proper construction necessary to insure the diversion of San Diego River into False Bay. Copies of these two drawings, together with a copy of his report on this whole subject, are herewith inclosed.

As both the field and office work mentioned in this report have been done under my immediate supervision, I do not think it necessary to enlarge on the results of this survey at the present time.

The prominent facts which this examination have developed ought, however, to be stated. They are as follows:

1st. That no injurious changes have taken place in the channel of the upper part of San Diego Harbor since 1856.

2d. If future examinations show that the San Diego River ought to be diverted into False Bay, we have ascertained the best and cheapest route for such diversion, and given a plan for the construction necessary to effect that object, which, if properly built, will doubtless prove entirely effective.

I remark, in conclusion, that the map of the upper portion of San Diego Harbor, made in 1872, taken in connection with the map of the lower portion made by Captain Heuer in 1869, furnishes the Department with a complete resurvey of San Diego Harbor, by which all the changes that have taken place in the channel since 1856 can be seen at a glance.

I have the honor to be, very respectfully, your obedient servant,

B. S. ALEXANDER,
Lieutenant-Colonel Engineers, Brevet Brigadier-General U. S. A.,
President Board of Engineers, Pacific Coast.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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OFFICE BOARD OF ENGINEERS FOR THE PACIFIC COAST.
San Francisco, California, January 16, 1872.

SIR: Herewith you will receive orders to proceed to San Diego, California, and make such observations as may be necessary to determine to what extent the harbor at that place is filling up, and the cause of the same.

The closing portion of my letter to the Chief of Engineers, dated April 25, 1871, of which you have a copy in the records of this office, will explain to you my theory on the subject.

I may be right or I may be wrong in the opinion I have formed and expressed as to the cause of the filling up of the upper portion of San Diego Harbor, and I wish you to understand that your investigation, while it will doubtless either confirm or disprove my theory, ought not to be confined exclusively to that object. It should have a wider scope:

1st. We wish to know if the harbor is actually filling up, and if so, to what extent.

2d. To ascertain the natural causes, if possible, which produce the filling.

3d. To determine the best method of arresting any further injury to the harbor.

To demonstrate the first two propositions a series of soundings across the harbor will be necessary. These should be reduced to the plane of mean low water for the purpose of comparing them with the Coast-Survey charts. From the soundings you made when you were in San Diego a year ago, I suppose there can be no doubt but that the upper portion of the harbor is gradually being filled up. From those you are now to make we will be able to determine to what extent the process has been carried up to the present time.

In order to ascertain the causes of this filling up, I suppose the proper way will be to obtain specimens of the bottom of the harbor at various points, both on the surface and at different depths.

Specimens of the sediment brought down by the San Diego River, and by the small streams at the head of the bay, in times of floods, should also be obtained.

A microscopic examination of the materials forming the bottom of the bay, at many places, when compared with those brought down by the San Diego River and other streams, will probably enable us to determine from whence the former are derived.

If you have a flood, while you are on this investigation, it will be well to take specimens of the muddy water from the San Diego and other streams, and evaporate them, retaining the sediment for microscopic examination. In fact, such specimens will give us the most satisfactory results. But if you do not have such a flood, then you should obtain specimens from the bottom of the harbor, at or near the mouths of the streams, and bring these for examination. In addition to the probable filling up of the harbor from the suspensible matter brought down by the waters of the San Diego River, it is possible that this filling up may be augmented by light materials carried by the prevailing summer winds from the littoral cordon in front of the upper portion of the harbor. If you will take specimens of the materials from the top of this sand-ridge and sift them, so as to obtain only those particles which the wind could carry, they will enable us to judge to what extent the cause operates.

In order to still further investigate this subject, I desire you to put down some eight or ten "sediment-boxes," say about 3 feet square. If the plan of those which you have already made is not suitable, you will

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of course, exercise your judgment in the matter, and alter them if necessary. These may be looked upon as artificial bottoms of little portions of the harbor, which can be taken up from time to time, particularly after floods, and examined. The sediment which they contain should be preserved for examination and comparison with those you will obtain from the sources from whence they must be derived. Two of these boxes ought to be placed at the upper end of the bay, two at the mouth of the San Diego River, and the remainder at different intermediate points. Some of these boxes I would put down on the bottom and anchor them there by weights placed in the boxes; the others I would support on little piles, say 4 by 4 inch scantling, so that they would stand just at low-water level, and a short distance above the bottom. All of them should be marked by "watch buoys," marked or numbered, so that they may be readily found and distinguished hereafter by a stranger. These buoys will also serve as some protection from passing vessels. Particular caution should be taken about those you place at the mouth of the San Diego River, for these will be liable to be washed away in a flood, and run over by vessels and boats.

If your investigations prove that the filling up of the harbor is owing to the sediment brought down by the San Diego River in times of flood, this river should be diverted so as to empty into False Bay.

Captain Heuer, of the Corps of Engineers, has recently investigated this subject, and you have before you the results of his investigations.

I wish you would look into this matter carefully, and report whether, in your opinion, the line of diversion which he proposes is the proper one; and if so, whether the slough, into which he proposes to divert the river, is of sufficient size to carry the flood-waters of the river, or otherwise, giving the breadth and depth of the slough in the most contracted parts; the nature of its banks, and whether there are any obstructions to the free delivery of the water from the San Diego River through it into False Bay; and any other information you may be able to obtain bearing on the feasibility of so diverting the San Diego River.

You are authorized to take an assistant with you, and also a boat and crew, if you think necessary, and pay their transportation going and returning.

Very respectfully, your obedient servant,

B. S. ALEXANDER,
Lieut. Col. Engineers, Brevet Brigadier-General, U. S. A.,
President Board of Engineers, Pacific Coast.

Captain THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

SAN FRANCISCO, CALIFORNIA, *April* 25, 1872.

COLONEL: In obedience to your order, dated January 16, 1872, I have made such an examination of San Diego Harbor, California, as was contemplated in your instructions of the same date, and I now have the honor to submit the following report.

The objects to be attained by this examination were:

1st. "To ascertain if the harbor was actually filling up, as reported; and if so, to what extent."

2d. "To ascertain the natural causes, if possible, which produce the filling."

3d. "To determine the best method of arresting any future injury to the harbor."

In the year 1869 an examination was made of that portion of this harbor between New San Diego and the bar, by Captain W. H. Heuer, Corps of Engineers, under the directions of Major R. S. Williamson, Corps of Engineers.

At that time it was reported that the bar, and probably the interior of the harbor,

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was shoaling, in consequence of the sand and sedimentary matter brought into the harbor by the San Diego River during its freshets.

After a careful and thorough examination and comparison of his work with the United States Coast-Survey chart of 1856, Captain Heuer arrived at the conclusion that since this date the condition of the San Diego Harbor had not materially changed. His report to Major Williamson on the subject can be found in the printed report of the Chief of Engineers for 1870, page 512.

His examination, although thorough so far as it went, and strictly in accordance with his instructions, was not considered as conclusive evidence that the harbor was not filling up.

It was thought that south of New San Diego, in that part of the bay not examined by him, deposits were being gradually made which would eventually result in injury to the harbor.

The theory was, that during the freshets of the San Diego River, the flood-tides would carry large quantities of suspensible matter into the upper or southern portion of the bay, which at slack water would be deposited upon the bottom. The ebb-tide being of low velocity in this locality would be unable to raise the sediment again, and it would thus gradually fill up this part of the bay.

This theory was somewhat strengthened by my report to you, dated April 7, 1871, in which I gave the results of some trial lines of soundings which you had directed me to make, roughly, between prominent points in the southern part of the bay. I have discovered during my recent examination that these trial lines, which were made without triangulation, and in cloudy weather, which rendered the points hardly distinguishable from each other, were erroneously plotted on the sheet which accompanied that report, and have therefore conveyed a wrong impression.

This, then, was the state of the case when I received my instructions from you to make a thorough examination of that part of San Diego Harbor south of the town of New San Diego.

On the 26th of January I embarked for San Diego, taking with me a boat and crew of four men, also an assistant, Mr. John F. Lewis, whose ability and zeal in the prosecution of the work I take this occasion to highly commend.

On the 29th of January we arrived at San Diego, and the following morning commenced our field-work.

After finding a sufficient number of Coast-Survey stations to enable us to connect and compare our work with the hydrographic chart of 1856, we put up eighteen signals on prominent points around the shore of the upper part of the bay. The positions of these signals were then determined by accurate triangulation. When this was done the soundings were made by rowing the boat with a steady stroke from one signal to another, and casting the lead at regular intervals of thirty seconds.

We ran in all about fifty-two miles of soundings, and cast the lead about eighteen hundred times.

The results were afterward reduced to the plane of the mean of lowest low water for each day during one lunation, as determined by the self-registering tide-gauge at La Playa, and plotted in *red*, on a tracing taken from the United States Coast-Survey chart of this portion of the bay, made in 1856. This tracing, which is herewith submitted, has on it also some sections taken across the bay at points where the greatest changes have taken place.

It will be seen, by an examination of this sheet, that no very material change has taken place, either in the depth or position of the channel, since 1856. In some places it has shoaled a little and in others deepened, but upon the whole it remains nearly the same.

In the vicinity of Horton's and Culverwell's wharves the water has shoaled considerably, and in consequence the channel there has been forced over toward the opposite shore. The position of Culverwell's wharf, it seems to me, is not well chosen, for it is on a portion of the shore where, even without its artificial aid, shoaling would naturally take place. It therefore hastens a result which should by all means be avoided.

The result which Kimball's wharf, at National City, will have upon the channel in that vicinity cannot now be ascertained, for it has been built but a short time.

In accordance with your instructions I placed a number of "sediment-boxes" at various places throughout the bay, the design of which was to ascertain, if possible, the amount and character of the deposit, if any, which took place during the freshets of the San Diego River. These boxes were merely a flooring 3 feet square, with pieces nailed upon the sides and projecting about 6 inches above the surface in order to catch any sedimentary matter that might be deposited.

A piece of scantling about 2 feet long was nailed to each corner, and served as legs for the flooring to rest upon. They were taken to positions where it was thought that deposit would most likely take place, and sunk by means of sand-bags and stones fastened to the outside. They are from 1 to 2 feet below the lowest tides.

Bearings to prominent objects in sight were taken from each in order that they may hereafter be readily found. A small watch-buoy was also attached to each to mark its

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position. Ten of these were placed in position, seven of which are shown on the accompanying sheet. The bearings from the remaining three will be found in the notes.

I also obtained specimens of the bottom at various places throughout the bay by boring to the depth of from 3 to 5 feet. These specimens are all alike in general character, being a very soft grayish mud mixed with sand. I can observe no difference beteen those obtained from the flats at the mouth of the San Diego River, and those from the upper end of the bay.

The "littoral cordon" which you mentioned in your instructions as a possible source of material for filling up this portion of the bay, I have examined with considerable care, and conclude that the part which it plays in the filling up is exceedingly small. This cordon is a long, narrow ridge of coarse sand and gravel which separates the water in the upper part of the bay from the ocean.

On the side next to the ocean and the prevailing winds there is little or no vegetation, but on the lee side, next to the bay, it is generally covered with grass and weeds, as are also the flats between the foot of the slope and the water of the bay.

In two or three very low and narrow places, of limited extent, the sand extends from the ocean to the bay, and here, at times, the sea breaks over, but this is only for a very short time during extreme high tides and strong gales. There is no danger of a permanent or damaging break at any of these places, because the same causes which first formed the ridge are still in operation, and they tend to strengthen rather than weaken this barrier, which separates the bay from the ocean. If this "littoral cordon" were encroaching upon the bay, the sand and gravel of which it is composed would be rolled up to its crest by the action of the wind and waves, and would then roll down by the action of gravity on the side next to the bay. All vegetation would be covered up and its growth prevented. But this is not the case, nor do the specimens obtained from the bottom of the bay in this locality indicate that they came from this source.

The prevailing winds, which are light, have not sufficient force to roll the sand up the side of the ridge facing the ocean, but the dust during high winds is raised and carried over into the bay. The quantity of this, though, I think is too small to have any appreciable effect upon the harbor.

Having shown that there are no natural causes in operation which have, since 1856, materially impaired the efficiency of this harbor, it may not be out of place here to call your attention to a danger from another source which seriously threatens it, and which, if not averted, will certainly impair its usefulness to such an extent that before many years large appropriations of money will be required to preserve it from utter ruin.

It is now a generally admitted fact that commercial considerations will soon render it necessary to build a railroad across the southern portion of the United States, and the western terminus of this road must be on the shores of San Diego Harbor. In this event there will be built numerous wharves, piers, slips, &c., to accommodate the shipping which will visit this port, and, as is generally the case, these will be located and built solely in the interest of present economy and present gain to those who are the originators of the scheme, and either through ignorance or avarice the future welfare of the harbor will be entirely lost sight of.

Already there are schemes on foot by means of which certain individuals are to get possession of the greater portion of the bay between high and low water, and they contemplate selling water-lots, which are to be filled up and built upon.

Now, San Diego Harbor is nothing more than a large slough, in which the tide ebbs and flows. There are but few streams that empty into it, and these are small and unimportant, and for years at a time perfectly dry. The San Diego and Sweetwater Rivers about once in two or three years bring down sand and mud from the neighboring hills for two or three months, then they dry up entirely.

The harbor, then, receives no benefit from the streams which empty into it. Its efficiency depends entirely upon the area of its tidal prism, and the quantity and velocity of the water which passes out over its bar. If the area of the prism is in any way diminished, the amount of water passing out is proportionately diminished, and the scouring effect upon the bar proportionately less. As the depth of water on this bar is, at best, but barely sufficient for the wants of commerce, it is therefore necessary that every precaution be taken to prevent its diminution.

Before this question is further complicated by the construction of wharves, &c., or the filling in of water-lots, the State, or the United States, or whoever is the proper authority in such matters, should pass the necessary laws to preserve the tidal area of this bay and avert this evil that so seriously threatens it.

A commission should be appointed, composed of men of known ability and long experience in such matters, whose duty it should be to carry out the provisions of the law, to prescribe the necessary rules and regulations, and determine the lines beyond which wharves, piers, &c., should not extend, and no "improvement" should be allowed without the approval of this commission. In this way we might hope to preserve one of the only two good harbors on the Pacific coast between Puget Sound and the Mexican boundary.

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Although the results of my examination show that no very material change has taken place in the upper portion of this harbor since 1856, and the conclusions of Captain Heuer are the same with regard to the lower portion, yet it cannot be positively asserted that it is now in as good condition as it was then.

For the commercial wants of the harbor for the last sixteen years the change is not appreciable, but for its wants in the future even a very slight filling up will be seriously felt.

All the evidence that we have goes to show that the San Diego River, during its floods, brings into the bay large quantities of sand and sedimentary matter, which, to say the least, do not do it any good. It is reasonable to suppose that, in the future, its effects will be more marked than they have heretofore been. The wharves, piers, &c., which are built and to be built, will obstruct the free flow of the water, and much of the sand which heretofore found its way into the ocean will be deposited in the bay. From this view of the case, I think it necessary that the San Diego River should be diverted back into one of its old channels and made to empty again into False Bay. In order to determine the most practical method of accomplishing this object, the ground in the vicinity of the river and False Bay was carefully examined and sections made along what seemed to be the most feasible route for the river to take. On the accompanying sketch, which shows the general features of the ground in this vicinity, the lines determined upon and run are indicated in *red*.

The line A C′ crosses the valley in what seems to have been an old outlet to a part of the river. This is the lowest ground between the old and the present river-bed.

The bed in which the river flowed previous to 1811 is at the northern end of this line. The section shows that it is about 3 feet below the present river-bed, and that but little excavation will be required to open a channel along this line.

The ground immediately on the lower side of this line is from 2 to 3 feet higher than the line itself, so that we already have a partial embankment for the water-way.

The section C′ *c*″ *d*, taken along the old river-bed, shows that the fall from C′ to *d* (high water of False Bay) is about 3 feet 3 inches, which would be more than sufficient to carry off the water.

The ground between the old and the present river-bed is from 3 to 4 feet higher than the left bank of the old river, so that when the water is once over to the north side of the valley there is no possibility of its getting into San Diego Harbor.

To divert the river from its present course it is proposed to go from 500 to 600 feet above the point A in the sketch and build a dam toward the northern side of the valley, and in the direction of the broken red line. This dam to be built by driving piles 14 inches square into the sand, 5 feet apart, and bracing them on the lower side with 12-inch piles. These main piles to be connected by three pairs of stringers, one at the level of the river-bed, one 4 feet above and the other 4 feet below. The stringers on the upper side of the piles, and the top one on the lower, to be 8 by 8 inches, the remaining two on the lower side to be 4 by 8 inches. Two rows of sheet-piles are to be driven along the upper stringers as guides. The first, 6 by 12 inches, and the second, breaking joints with it, 4 by 12 inches. Three stringers 4 by 8 inches are then to be placed outside of the sheet-piles, and the whole fastened to the main 14-inch piles by 1¼-inch iron bolts. The piles are all to be 30 feet long, and driven into the ground 24 feet below the river-bed, or less, if the nature of the ground, which is generally a quicksand, will admit of it. The height of the dam above the river-bed will be 6 feet.

On the upper side of the dam, for a width of 20 feet, and a depth of 4 feet below the river-bed, the sand is to be excavated, and three rows of fascines placed in the trench. The first and third rows will be perpendicular to the dam, the second parallel to it. On top of the fascines rock will be piled, in order to hold them in place. The plan and section shown on the accompanying sketch will show more fully the construction of the dam.

It is thought that 1,000 feet will be sufficient for its length. It may not be necessary to build it of this strength the whole of this distance. Some 500 or 600 feet should be built thoroughly strong, to avoid all possibility of a break; the remainder may be made a similar but lighter structure.

In order to provide ample water-way for the river, a channel about 400 feet wide should be excavated across the valley. The sand excavated from this, and thrown up on the lower side, would give additional strength to the embankment which is already there.

When the water is once into the old channel the nature of the soil is such that it would soon enlarge it sufficiently for its accommodation. Some little excavation would perhaps be necessary at C″.

The following is the estimated cost, in coin, of 100 feet of the dam:

50,500 feet lumber, at $30 per thousand	$1,515 00
Driving 40 piles, at $10 each	400 00
Driving 200 piles, at $5 each	1,000 00
601 ¼-inch bolts, 17 pounds each, 1,020 pounds, at 10 cents per pound	102 00

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300 fascines, at $2 each	$600 00
160 cubic yards rock, at $3 per yard	480 00
400 cubic yards excavation, at 25 cents per yard	100 00
	4,197 00
Add 10 per cent. for contingencies	419 70
Total cost of 100 feet	4,616 70

Cost of dam 1.000 feet long, $46,167. In addition to this about 60,000 cubic yards of excavation will be required to open a channel for the river. This, at 25 cents per yard, will cost $15,000, making the total cost of turning the river $61,167, in coin, or about $68,000 currency.

If the following plan and estimate meet your approval, and that of the Chief of Engineers, I would respectfully suggest the propriety of recommending that the full amount of the estimate be appropriated before the work is commenced, so that it could be rapidly completed. This work is of such a nature that it cannot be left in a partially completed state without running too great a risk of its being destroyed by a sudden flood of the river.

In addition to the line A C′, which is recommended as the best on which to turn the river across the valley, I ran another (D E) about a mile above, at a point where it was thought the river might be turned with advantage. The section on this line shows that it is not near so favorable as the one chosen; besides, the difficulties of preventing it from breaking back into its old channel are such as to preclude the idea of a dam at this place.

Accompanying this report I have the honor to transmit two maps, (tracings,) one entitled a hydrographic survey of the southern portion of San Diego Harbor, showing the changes which have taken place since 1856; the other, a sketch of San Diego River, showing the proposed method of turning it into False Bay.

The total amount expended in making these examinations, preparing the maps, &c., was $1,013.52.

Respectfully submitted.

THOS. H. HANDBURY,
Captain of Engineers.

Lieutenant-Colonel B. S. ALEXANDER,
President Board of Engineers for the Pacific Coast, San Francisco, California.

X I.

ANNUAL REPORT OF MAJOR G. H. MENDELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

OPERATIONS ON THE BREAKWATER AT WILMINGTON, CALIFORNIA.

At the beginning of the fiscal year no work had been done on the breakwater, and no preparations for beginning work had been made, except that a project for the improvement had been submitted. This project was offered on the 1st day of July, and on the 14th day of the same month telegraphic instructions were given by the Chief of Engineers to buy in open market the timber required for the first section of the work, 3,700 feet in length, and also to advertise for proposals for its construction.

In obedience to these instructions offers for the timber were solicited from the principal lumber-dealers in San Francisco, and in reply the following bids were received, viz:

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Abstract of offers for timber required for first section of Wilmington breakwater, July, 1871.

No.	Name.	Timber delivered at San Pedro.	Timber first delivered at San Francisco and afterward at San Pedro.
		Per thousand in coin.	Per thousand in coin.
1	Mastick & Co.....	$17 50	$24 00
2	Hanson, Ackerson & Co...	17 00	22 00
3	Pope & Talbot.....	20 00	27 00
4	Benton, Smith & Co.....	16 00	21 00
5	Phineas Banning.....	21 50	25 00

N. B.—The last offer included the piling of the timber on Rattlesnake Island, adjacent to the work.

The offer of Benton, Smith & Co. being the lowest, was accepted.

The portion of the timber which it was thought necessary to treat by a preservative process was first brought to San Francisco, treated by hydrocarbon oils, and reshipped to Wilmington. The cost of treatment was $10 in coin per thousand feet, board-measure.

The timber was delivered at the anchorage by Benton, Smith & Co., where it was received by the Los Angeles and San Pedro Railroad Company, by whom it was rafted to Rattlesnake Island, and piled adjacent to the work at a cost of $3.50 per thousand feet. About 1,400,000 feet were delivered at the anchorage and piled on Rattlesnake Island during the autumn months.

On the 14th of August, after due advertisement, bids for the construction of the first section of the work were opened, and the lowest bid, that of E. M. Benjamin, was accepted. The contract was signed at once.

Owing to some unexpected delays, the contractor was unable to begin the work until the early part of October, from which time until the 6th day of December he prosecuted the work with energy and with as much success as could be expected from an insufficient equipment. On the 6th December the contractor notified me that he should proceed no further in execution of the work. He was paid for the work done at the end of October and of November, in accordance with the stipulations of the contract, 25 per cent. being reserved. He was paid for 347 feet in all, less 25 per cent. The circumstances attending this failure of Mr. Benjamin to fulfill his contract having been fully set forth in my letter of the 8th February, it is not necessary to refer to them further in this report.

During the month of November the work began to be threatened with undermining, and the danger of serious injury increased and continued imminent for the next two months. This difficulty arose from an obstruction placed across the usual route of the tidal waters as they filled and were discharged from the bay. The sand into which the piles were driven was so light that it offered no resistance to a current, but was washed out without opposition on its part.

Lieutenant Sears, who had been at the work as my assistant, took energetic measures to combat this effort of the tides, and, by means of brush and small cribs, so arranged as to break the continuity of the currents, he was able after considerable difficulty to make the work safe.

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At this time great benefit was received from a source which ordinarily would be expected to bring rather disaster than relief. The southeasterly storms of the winter, while they tried severely the stability of the piling, weakened as it was by the withdrawal of the sand upon which it depended mainly for its power of resistance, supplied anew the sand which had been washed away. They filled in large quantities of sand on both sides of the work, and while they insured its safety they also fulfilled the anticipations that the work would serve to extend the bulwark of sand in the line of the work toward Deadman's Island.

Bids were opened on the 11th December for 2,000,000 feet of timber, to be used in the construction of the next section of the work. But two bids were received, and one of these was intended to relieve the appearance of the combination which had been arranged among the lumber-dealers to secure a higher price than was justified by the conditions of the market.

The real bid, as well as the lower, was that of Benton, Smith & Co., viz, for timber delivered at San Pedro direct, $23.50; for the portion reshipped at San Francisco, $30.50 per thousand, both prices being in gold coin.

The contractor having relinquished work on the construction, and there being no possibility of resuming it before spring, it became possible to reject these offers without delay in the construction. The offer of Benton, Smith & Co. was declined.

A new advertisement, calling for bids on the 12th January, was sent to the War Department for approval. The obstruction of the mails by snow prevented the receipt of a reply to this application in time, and on the 6th January offers were solicited by circular.

The bids received are appended, marked A. The offer of George W. Prescott & Co. was accepted. Under this agreement about 1,000,000 feet have been delivered, and there yet remain to be delivered about 250,000 feet.

On January 17 the Chief of Engineers directed that the work, instead of being re-advertised, should be constructed by hired labor. Preparations were made at once to provide an equipment which should enable one party in the working season to build 4,500 feet, less 405 already constructed, or about 4,100 feet. Six steam pile-drivers were provided. It was also necessary to provide some temporary building for the shelter of the men, a blacksmith-shop and office, all of which are located near the work on Rattlesnake Island. Other preparations were necessary, such as a large tank placed high enough to deliver water to the engines on the work, a water-boat to bring water from Wilmington, two miles distant, and some others of minor importance. These preparations, embarrassed greatly by inability to procure engines and parts of the pile-machines, due to the obstructed and crowded condition of rail and common roads, consumed several months, and it was not until near the end of June that the whole equipment was ready and fully at work. Three drivers were at work, however, in the latter part of May.

The mode of construction is as follows, viz: The foremost driver is arranged to reach out 10 feet in front of the work. It drives the scaffold-piles, which are 10 feet apart, in the direction of the work, in pairs. Upon these stringers are laid, and other timbers, at right angles to these, give a platform 30 feet wide, upon which the drivers are worked. The next driver drives the brace-piles 5 feet apart, at an inclination to the vertical of 30°. Driver No. 3 drives the uprights 5 feet apart. Drivers Nos. 4 and 5 are expected to drive the sheeting-piles. Driver No. 6 works as

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opportunity may offer, and follows in rear, taking up the scaffold as the work is finished.

To counteract the undermining action of the current, at intervals of 100 feet or less, on the inside, a number of wings are placed at right angles to the work, which it is hoped will break up the current, and, by creating sheltered places and forming eddies, will favor the deposition of suspensible matter as well as protect the sand by direct action.

At the end of the work nearest Rattlesnake Island, the sand extends to a depth beyond the reach of the piles. Indeed, it is found that 15 feet penetration is about the limit of penetration. To attain this sometimes 150 blows are necessary, with a 2,400-pound hammer, and falls of 6 to 10 feet, regulated to save the head of the pile. The last blows penetrate the sand about one-fourth and not more than one half inch.

Farther toward Deadman's Island, a hard face comes within a few feet of low water. This it is supposed will not be abraded under the action of the current, and a few feet of penetration in this material will give a power of resistance to flotation, which cannot be attained where the only material is sand that may be said to float in the water.

Difficulties may yet be expected in the construction, and inasmuch as their extent and the consequent expense attending them cannot be closely predicted, it will not be possible to give estimates for the future with the definiteness to be desired. The only safe rule, in cases of this kind, is to make the estimates sufficiently large to cover all contingencies.

The condition of the work on the 30th June, 1872, was as follows, viz: The scaffold was built for 1,900 feet, 380 piles; the brace-piles driven for 1,640 feet, 328 piles; the uprights driven for 1,380 feet, 276 piles; the sheeting driven for 415 feet, 747 piles. Eight hundred and thirty feet of the work completed, of which half was done by the contractor. In addition eight wings of similar construction to that of the main work were put in.

There is now on hand or on the way timber sufficient to complete the work laid out for the summer, which will bring us within 2,000 feet of Deadman's Island. We here reach a point where the work will begin to be exposed to more severe blows from the sea, and where there is less reason to expect it to be covered by accumulating sands. Here also a timber construction would be exposed to unintermitted attacks of the *Teredo navalis*. For these reasons it is apparent that a construction of stone is preferable to one of timber or of timber and stone combined.

Acting upon these views, with the approval of the Chief of Engineers, an advertisement was issued calling for bids for stone. In reply a number of offers were made. No action has as yet been taken on these bids. Some delay was necessary to permit an examination of the deposits from which stone was offered. Added to this, there was considerable uncertainty as to the amount of money that would be absorbed by the work laid out for the summer. The time for action, however, cannot be long delayed. A part, at least, of the last appropriation of $75,000 may be applied to this purpose.

The stone part of the work, if made, will consist of riprap work rising to half tide, and permitting the flood and ebb tides in part to make their way over it. In this way facility is offered to the sea to fill the inner bay, which it might fail to do with an entrance too restricted, and at the same time confine the ebb tide within the channel during that portion of its course where the scouring action is most observable.

First Lieutenant Sears, of the Corps of Engineers, is at the work.

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He devotes his whole attention to his duties and performs them with intelligence.

There yet remains to be completed the investigation of the mouth of the harbor. This was partially done during last year. Lieutenant Sears has not as yet been able to give enough time to complete this work, but probably it will now soon be accomplished.

The work for the coming year will be the construction of 2,000 feet of the work next Deadman's Island and such cutting or dredging near the mouth as may be found necessary. It is probable, from the observations that have been made by borings, that it will be necessary to deepen, by artificial means, the waterway near the mouth of the estuary. An indurated sand, too hard to be rapidly worn by the current, which is easily bored by a steel auger, into which piles can be driven unshod, comes within five or six feet of low water, and it is probable that, for the proper accommodation of sea-going vessels, it may be advisable to cut this to a depth of four or six feet. It is this point which Lieutenant Sears has not yet fully investigated.

Respectfully submitted.

G. H. MENDELL,
Major of Engineers.

SAN FRANCISCO, CALIFORNIA, *July* 31, 1872.

—Abstract of offers for timber for second section of Wilmington breakwater, January, 1872.

No.	Name.	Timber delivered at San Pedro.	Timber first delivered at San Francisco, and afterward at San Pedro.
		Per M. in coin.	*Per M. in coin.*
1	Rentin, Smith & Co	$20 50	$25 50
2	Adam Blinn & Co	24 00	29 00
3	G. W. Prescott & Co	21 00	25 00

—Exports and imports of merchandise at the port of Wilmington, California, during the year 1871.

EXPORTS.—9,575 tons (weight) merchandise.

IMPORTS.—25,006 tons (weight) merchandise.
307 tons (measurement) merchandise.
10,938,336 feet of lumber.

NOTE.—One hundred and sixty steamships and 65 sail-vessels arrived at San Pedro ring the year, receiving and delivering freight.

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APPENDIX Y.

ANNUAL REPORT OF MAJOR O. E. BABCOCK, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS,
Washington, D. C., September 4, 1872.

GENERAL: I have the honor to submit the following report of operations on the works under my charge for the fiscal year ending June 30, 1872.

EXECUTIVE AVENUE.

Work was commenced on the avenue July 1, 1871, and has been prosecuted during the year with the following results:

The avenue was opened through to Pennsylvania avenue opposite Sixteenth street, and the earth taken from it was deposited in the inclosed grounds south of the Executive Mansion and in the White Lot. The trees that were removed, furnishing some twenty cords of wood, were given to the Soldiers and Sailors' Orphan Asylum located in this city. All the stone piled on and around the avenue has been collected, broken and properly placed on the roadway, and an additional quantity of 300 cubic yards purchased for the same purpose. Six granite gate-posts have been put in position at the western entrance to this avenue from Pennsylvania avenue, to which have been hung iron gates, the whole being uniform with the gateway on Pennsylvania avenue west of the Treasury Department.

The necessary lamp-posts have been set and the gas-main has been laid along the east side of the avenue. The stone walk and iron fence have been completed along the east side of this avenue to Pennsylvania avenue, corresponding with the walk and fence already in position, the whole thus presenting a uniform appearance. The Executive grounds along the line of the avenue have been graded, terraced, and sodded, and a stone gutter has been laid to receive the drainage from the terraces. A large quantity of old sand-stone, the property of the Government, and which was useless for other purposes, was used for the gutter. This gutter connects with a 10-inch sewer running through the inclosed grounds south of the Executive Mansion which leads into the sewer running to the canal. In laying this 10-inch sewer through these grounds, openings were left, into which drain-tiles can be led if it shall be decided to drain them.

A granite staircase of steps 20 feet wide has been built upon the terrace where the walk leading from the Executive Mansion to the War and Navy Departments crosses the avenue, and the gravel of which these walks were made has been removed and an asphalt walk substituted in its place.

The iron fence leading from the Mansion to the Treasury Department was removed and placed along Executive avenue and a light wire fence substituted in its place.

The entrance to the Executive avenue opposite Sixteenth street has been concreted with the same material laid on Pennsylvania avenue.

Part of the flagging, and all the gutter along the west circular walk leading from the Executive Mansion to Pennsylvania avenue, has been

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taken up and relaid in order to secure good surface drainage and to prevent water standing at the gates after heavy rains.

The large iron fence along the circular drive in front of the Executive Mansion has been removed, the foundation taken up, and the ground filled, graded, and sodded. The removal of these division fences throws all the ground in front of the Executive Mansion, bounded by Pennsylvania avenue in front and Executive avenue on the east and west, into one open and extended lawn, increasing the view and making the grounds appear more extensive.

Part of the old fence on Pennsylvania avenue has been removed and the curved fence straightened and substituted in its place, thus making the fence in front of the Executive Mansion uniform. The sidewalk on Pennsylvania avenue in front of the Mansion has been widened to a uniform width, and is now thirty-four feet six inches wide, where in places it was but fourteen feet and six inches.

GROUNDS SOUTH OF THE EXECUTIVE MANSION.

The inclosed grounds south of the Executive Mansion have been graded, sown with grass-seed and oats, and rolled. Water-pipes, with street-washers attached, have been carried into them, and walks made and repaired, and surface drainage made on each side of part of the walks. Upward of sixty trees of different varieties, and varying from three to eight inches in diameter, have been removed to these grounds from other reservations where they were too much crowded. They have been staked to keep them in proper position, and only one of them has died, owing to the care taken to keep them well watered.

The flag-staff in these grounds, being rotten and dangerous from the liability of its being blown down, was removed, and a very fine one, some 73 feet high, has been, through the kindness of Rear-Admiral Goldsborough, commanding the Washington navy-yard, erected in its place.

LAFAYETTE SQUARE.

The walks in this square were made of very coarse, unscreened gravel, and very unpleasant to walk upon. The experiment of rolling them with a 3,600-pound roller was tried, but did not succeed in making them hard and smooth. They were then taken up, the gravel thoroughly screened and relaid, putting the coarse gravel at the bottom and covering with the small after mixing it with still finer gravel possessing a binding quality. The walks were then thoroughly rolled, and the result is a hard, compact, and smooth foot-way. These grounds have been thoroughly drained, and eight lamp-posts, two of which are lamp-posts and drinking-fountains combined, have been placed in position, to which necessary connections of water and gas were made.

Water-pipes have been led into the square to which are attached four street-washers.

A watchman's lodge, of handsome design, has been erected on the north side of the square, combining a lodge, tool-house, and urinals for the accommodation of gentlemen and for nurses and children, at the different ends of the building, the latter especially supplying an accommodation long needed in this square. The building is approached at the ends by circular walks, screened by thick rows of evergreens upon each side, and in front flower-beds have been laid out and small shrubs planted, the whole forming a very handsome addition to the square.

Two beautiful bronze vases, copies of an antique vase, have been.

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placed on the granite pedestals. They were cast, through the kindness of the Hon. George M. Robeson, Secretary of the Navy, at the brass foundery of the Washington navy-yard. They are some 7 feet high, and weigh some 1,300 pounds each. They are very finely executed, and an honor alike to Government workshops and the mechanics who constructed them.

Originally the trees were planted closely in this square, with the intention of removing them as they obtained their growth and overshadowed each other. To benefit some of the more valuable specimens, a number of trees which crowded them were taken up and removed to the grounds south of Executive Mansion.

FARRAGUT SQUARE AND RESERVATION, ON NEW YORK AVENUE BETWEEN EIGHTEENTH AND NINETEENTH STREETS.

The improvement of Farragut Square and the reservation on New York avenue between Eighteenth and Nineteenth streets has been commenced by removing part of the worthless soil and replacing it with good.

In Farragut Square gas and water pipes have been introduced, the water to be used for irrigation and drinking purposes. This square will be improved on a plan similar to Scott Square, with the exception that an ellipse will be made in its center, to receive the statue of Admiral Farragut, which was voted for this square at the last session of Congress.

SCOTT SQUARE.

In accordance with a plan agreed upon by the board of public works and myself for the improvement of Scott Square, I have allowed a road-way 24 feet wide to be cut diagonally through it and running in a line with Vermont avenue. In consideration of this, the grounds have been extended 12 feet on each side and 20 feet on K street, and the roadway curbed, graded, and concreted by the board, which has been done to my satisfaction.

Further improvements have been made by inclosing with an iron post-and-chain fence, thoroughly grading, top-dressing, introducing gas and water for irrigation and drinking, the erection of a gas-lamp and drinking-fountain combined, by concreting the walks, and sodding a small strip around the entire square and on each side of the walks and all that portion lying between the roadway and the walks running parallel with it. The rest of the square has been sown with grass-seed, and oats. No appropriation is asked for this square for the coming year.

THE CIRCLE AT INTERSECTION OF MASSACHUSETTS AND VERMONT AVENUES.

The trees, plants, shrubs, &c., planted in this circle having nearly all died, an examination was made, and it was discovered that the soil placed therein when the circle was first inclosed and graded was placed on the old road-bed, and but about one foot in depth. To correct this the old road-bed was removed and replaced with good soil, mixed with a compost of canal-muck, manure, and lime, and the whole properly graded and sodded.

After very unsatisfactory attempts to get bids from different parties

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in this country to construct stone coping for a foundation-bowl for this circle, I ordered a terra cotta one from Scotland. This coping has been received and placed in position, and the necessary foundation and bowl prepared together with pipes, &c.

A set of rustic stone furniture purchased by my predecessor, consisting of eleven pieces, one of which is a center-piece for a fountain, has been received, the fountain-piece being placed in the center of the bowl prepared for it, and the furniture placed on properly constructed foundations, to prevent its being thrown down and broken.

Rustic and wooden seats have also been placed in this circle. A choice selection of evergreens, trees, plants, shrubs, and flowers has been planted and has been well watered during the dry season, but for which a large number of them and the sod would have died.

The walks have been laid with asphalt, the fence painted with two coats of paint of a bronze color, and the whole circle is in good condition.

No appropriation is asked for this circle for the coming year, other than for ordinary care, which the watchman in charge will be able to give.

The circle at the intersection of Massachusetts, Connecticut, and New Hampshire avenues has been partially graded and some three feet of good soil has been deposited therein, which was obtained from the avenues in its immediate vicinity. The best soil only was taken, so that the rapid growth of such trees as may be planted there should be insured.

Lamp-posts and water-pipes, with street-washers attached, have been placed in this circle, thus securing a plentiful supply of both water and light.

FRANKLIN SQUARE.

The walks in this square have been reconstructed in a manner similar to those in Lafayette Square, and they are now hard and smooth and are not disagreeable to walk upon.

The drains not being in working order, and in some places, but a few instances, under the ground, it was found necessary to take them up and relay them at a depth of three feet, in order to protect them from the action of frost.

A portion of this square has been graded and sodded. A new brick walk has been laid on Thirteenth street, and the walk on Fourteenth street extended to the iron fence.

While repairing the pipes leading from the spring in this square to the Executive Mansion, connection was made with the Potomac water pipes and led into the square, the object being to prevent the necessity of taking up the sidewalk and street again in case it should be decided to introduce water for irrigation or for a fountain.

The fences around this square and in front of it on K street have been painted with two coats of paint.

MONUMENTAL GROUNDS.

The amount appropriated for the improvement of the Monumental Grounds has been expended in constructing an avenue, some 69 feet wide, from the high grounds north through the marsh to the canal, to connect with a corresponding avenue running south from the Executive Mansion, to be called, when completed, Meridian avenue.

The earth for this purpose was taken from the high banks along the

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river front of the Monument lot while grading for the drive-way which is to follow the line of the river bank.

SMITHSONIAN GROUNDS.

The Smithsonian Grounds have had the necessary care and attention, and a watchman's lodge has been erected on the site near Seventh street, from which the building heretofore used for that purpose was removed, it being private property.

PAINTING.

The iron fences around the War and Navy Departments and Lafayette Square have been painted with two coats of paint, the color being changed from black to bronze, believing it a more durable as well as a more pleasing color.

The wooden and iron seats in the public grounds have been painted, bronzed, and varnished.

WHITEWASHING.

All the wooden fences inclosing reservations under my charge, except the Smithsonian Grounds and Armory Square, have been given coats of brown wash, which was substituted for whitewash, because it does not become dirty so soon, and the reflection of the sun is not so glaring and uncomfortable during the hot days of summer.

PROPAGATING-GARDEN.

The forcing-houses at the propagating-garden have had all necessary repairs, and one entire new one has been constructed. The boiler in these houses not being of sufficient capacity to thoroughly heat them, it was removed and a larger one substituted in its place, and no trouble has since been experienced, nor were any plants lost for the want of sufficient heat during the extraordinary cold of last winter.

A large number of green-house and hot-bed plants of varieties not heretofore cultivated in this garden have been purchased and propagated from. Some 22,000 papers of flower-seeds were collected and cured, which, together with some 11,125 surplus plants, consisting of roses, chrysanthemums, verbenas, geraniums, begonias, and other hot-house and annual plants and shrubs, propagated at this garden, have been distributed to Members of Congress and others who were notified by circular letter that such stock was ready for distribution to them.

EXECUTIVE MANSION.

The forcing-house in the Executive Mansion, which was removed in excavating for Executive avenue, has been rebuilt. In its construction all the old material suitable was used.

A portion of the furniture in the Mansion has been repaired, varnished, and upholstered.

The roof has had all repairs the appropriation would allow. The carpets have all been taken up, properly beaten, sprinkled with camphor to prevent their being moth-eaten, and replaced. The curtains have also been taken down and repaired, done up, and replaced.

A quantity of acacias, camellias, and other green-house plants have been purchased for the green-house attached to the Executive Mansion.

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The lead in the tank that supplies part of the Mansion with water being worn out, and the tank leaking in consequence thereof, new lead was substituted in the place, and since then no trouble has been experienced.

BRIDGES.

The navy-yard and upper bridges have required constant attention, and have been kept in good repair during the year. Lamp-posts have been placed at the ends of the bridges and are regularly lighted.

During the year one hundred seats of the pattern used in Druid Hill Park, Baltimore, and three hundred and seventy-five seats of the close pattern, have been purchased and placed in the public grounds. These seats are made of wood and iron, the frame being of iron, and the seat and back strips of ash. These are believed to be more comfortable and less costly than, and are not so liable to get broken as, those made wholly of iron, and are more easily repaired. The people avail themselves of this provision for their comfort, and the seats are nearly all the time occupied. They have been firmly fastened in the ground, to prevent them being moved around upon the grass, which would very soon be wholly destroyed in front of them.

The fish-pond west of the Capitol has been thoroughly cleaned and the pile of stones in it removed. It was found that this pile of stones, instead of being a protection for the fish, was but a harbor for eels, some thirty of which, varying in size from 6 inches to 3 feet in length, were killed. They are very destructive to the gold-fish, and to prevent their getting into the pond again wire screens were attached to the inlet and outlet pipes. It is thought that, with the precaution taken, the fish will increase rapidly, and in a few years quantities of them can be distributed and placed in the various fountains in the city.

A quantity of terra-cotta tree-markers of different patterns were placed upon the trees, shrubs, and other plants in Lafayette Square and the Smithsonian Grounds, marked with their common and botanical name and their indigenous locality. Very few of these markers now remain, as they were wantonly broken and carried away, though they cannot be diverted to any other use.

A quantity of bird-houses have been manufactured and placed on the trees in the public grounds, and some one hundred pairs of German and English sparrows purchased and liberated, and now occupy all the cages. These birds are very valuable in the public grounds from the fact of their subsisting almost exclusively upon the larva of all kinds of insects, and as they are not migratory they live upon such larva, and thus prevent its maturity. They are very productive, each pair raising several broods of young each year, and the present stock of these birds, amounting to hundreds of thousands in New York City, is the progeny of a few pair that were imported in 1860 from Germany.

Some 3,200 loads of canal-muck was hauled into the White Lot, thoroughly mixed with stable-manure and lime, and distributed on the public grounds, and the result proving so beneficial, 8,500 loads more of the same material have been hauled in the same lot, to be prepared in the same manner and to be used during the coming season as a top-dressing on the grounds.

The supply of water in the cisterns at the Executive Mansion and the War and Navy Departments having become very much reduced, it was found upon examination that a greater part of the water from the springs in Franklin Square that supply these cisterns was passing down Thirteenth and other streets. To correct this, the line on Thirteenth

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street was connected with the pipe leading to the Executive Mansion and led into the square, where a stop-cock was placed, thus placing the flow of water entirely under my control. The line was also shortened on New York avenue. Since this work has been done no trouble has been experienced, and the cisterns have a more plentiful supply of water than they have had for years.

My foreman, who is a practical gardener, visited the northern nurseries during the spring and purchased a quantity of such trees, evergreens, shrubs, and plants as were deemed essential for the proper ornamentation of the public grounds. By purchasing this stock at the nurseries, none but the finest specimens were selected, which were obtained at the lowest prices. This course was found necessary, as the varieties wanted are raised in this vicinity only in very small quantities.

The different inclosed reservations not enumerated in this report have received necessary care and attention so far as the means at my disposal would allow, and in several of them a number of trees and evergreens have been planted.

The snow and ice have been promptly removed from the walks under my charge.

Such trees in the different reservations as were affected with mildew and blight have been washed with a preparation to destroy it, and to kill the larva deposited on them by insects. About fifty bushels of cocoons of the basket-worm, one of the most destructive of caterpillars, have been removed from the evergreens in the public grounds during the winter.

The fountain-bowls in the west Capitol Grounds have been thoroughly cleaned, the coping reset, reclamped, and calked, the inside of the bowls packed with clay and cemented, waste-pipe laid, and artificial rock-work placed in the center of each.

During the progress of this work much damage was done to the coping by defacing it with red pencil-marks and the throwing of sticks, &c., into the fountain-bowls, thus stopping up the waste-pipes and causing overflows. The statuary has been mutilated and the seats broken in these grounds, which I have had no means of protecting, as the watchmen in charge are not under my control.

No serious injury has occurred during the winter to any of the gas or water pipes from freezing.

No one employed by this office during the year has suffered from any accident, nor has any casualty occurred. Mr. W. M. Adams, policeman at the Executive Mansion, died on the 16th of June, 1872, of consumption.

A portion of Judiciary Square has been rented for $50 per month, for the purpose of preparing material for asphalt pavements and the money has been donated to the Women's Christian Associaition, which occupies the buildings adjacent to the ground rented.

During the year the reservation on Sixth street has been rented to circus and menagerie companies, and the money has been in part donated to the Soldiers and Sailors' Orphan Asylum and the Children's Hospital, the latter being a benevolent institution open alike to all classes of children.

I am pleased to report that the sum of $385 was voluntarily contributed for the relief of the sufferers by the Chicago fire by the employés of this office, who are mostly laboring men, and the amount was duly sent to the relief committee at Chicago.

It is with deep regret that I feel compelled to report the fact that there are a class of persons in this city who think it no crime to destroy any-

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thing belonging to the Government. The wooden fences are broken and carried away, the houses placed in the trees for the protection of the sparrows and other birds have been broken, and the birds themselves stoned from place to place. The seats in a few instances have been broken, and nearly all of them torn from their fastenings. The flowers are broken from magnolia and other trees when in bloom, and after, to their great injury. Limbs are broken from the larger trees, and some of the smaller trees are nearly ruined by having their leaders broken, which spoils the symmetry of the tree. The grass is walked on, and in some places walks across it have been worn; to prevent which, wires have been placed to keep people in the walks.

In trying to improve, beautify, and adorn the various inclosed reservations in the city, by planting choice and rare shrubs and flowers in them, the assistance of the citizens who reside here should be confidently expected to protect them, as such improvement is made more for their benefit than for that of the Government. In this connection, I am glad to say that all applications to the chief of police for assistance have been received with kindness and promptly answered, and the public press has ably seconded my efforts in this direction.

The water-pipe leading from Smith's Spring, and which supplies the Capitol with water, has been tapped by one W. E. Clark, for the purpose of supplying a hog-yard near the Baltimore and Ohio Railroad depot, and in accordance with the act of Congress, approved July 25, 1866, I notified the United States district attorney thereof.

I would state that the expenditures of the office have not exceeded the amount appropriated by Congress, and therefore no appropriation to cover any deficiency will be required.

The steps taken for the prosecution of the works for the fiscal year ending June 30, 1873, are as follows: Advertisements have been, and will be, issued, asking for proposals to do all work of such a nature as can be advantageously done by contract.

The work necessary to improve the public grounds is of such a character that it cannot be done by contract, and it will be done by day's labor, and a large force is now at work. Those improvements, with appropriations large enough, will be completed during the present fiscal year, as well as all the work to be given out by contract, including the Chain Bridge.

Attention is respectfully called to the appropriations asked for, to complete the improvements of certain public grounds described in my letter to Congress, dated May 14, 1872, a copy of which accompanies this report, in answer to a House resolution of April 8, 1872, asking for a detailed statement of the Government reservations in and around Washington, their area, and a detailed statement of the cost of putting certain named grounds in good condition. Those amounts are embodied in my estimates for the next fiscal year.

An amount sufficient to construct a fountain in the Smithsonian grounds has been added to these estimates, to enable this office to complete their improvements in accordance with the plans of Mr. Downing, the landscape gardener, who first laid them out.

Attention is also called to the item for granite coping for the iron fence in front of the Executive Mansion, which is intended to be used in place of the present coping, which is of sandstone, badly defaced and worn, thus making a continuous granite coping on Pennsylvania avenue, similar to the coping of the fence on each side of the Executive Mansion, and making the entire coping surrounding the Executive Mansion uniform.

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Birds and animals have been frequently offered this Department to place in the public grounds, which I have been unable to accept from the fact of having no suitable place to keep them. A small sum is asked to enable me to build cages, sheds, fences, &c., for this purpose. There is no feature that will add more to the attractiveness of the public grounds than the introduction of a few birds and animals.

As reservation No. 17, formerly selected as a site for a new jail, has been abandoned by the commissioners appointed by the last Congress to select such site, its care has reverted to this Department. This reservation contains some twenty-three acres, and could be made very beautiful and attractive. The amount asked for is not sufficient to entirely improve it, but would grade, drain, and outline the walks and roads, and plant trees, &c., and make what has heretofore been a waste and a nuisance a beautiful park. There being no improved reservations in this vicinity, and that it is being rapidly settled and improved by the city, are good reasons why this reservation should be improved, to say nothing about its close proximity to the Capitol.

The amount asked for for the Washington circle, on Pennsylvania avenue and Twenty-fourth street, is intended to be used to drain, introduce water, and to reconstruct the walks.

It having been decided to place the Scott statue on Sixteenth street, where Massachusetts and Rhode Island avenues intersect, I have included in my estimates a sum sufficient to improve the reservation at that point in a manner commensurate with the statue.

The estimate submitted for the improvement of Stanton Place, four triangular reservations on Pennsylvania avenue, east of the Capitol, and for various reservations on different avenues, is intended to be used in keeping pace with the rapid and magnificent improvements being made by the city under the able direction of the board of public works. These reservations are in the eastern part of the city, which is growing rapidly, and their improvement will be the first the Government has made in that locality for years, with the exception of Lincoln Square.

It having been decided by the District authorities to remove the Northern Liberty market from its present site, the ground reverts to the care of this Department, and being situated at the intersection of Massachusetts and New York avenues on Seventh street, and in a locality densely populated and far removed from any improved reservation, an estimate is submitted for its improvement, and the reservation immediately west of it.

As the present jail will probably be removed from Judiciary Square the coming season, and the amount appropriated for the present fiscal year is not sufficiently large to complete the improvements contemplated, I have deemed it advisable to make the present estimate, which it is thought will be ample to complete them.

LINCOLN SQUARE.

The estimate submitted for this square is thought sufficient to complete its improvements by inclosing it with iron posts and chain, completing walks, building lodge, with urinals for both sexes, and embellishing it in a manner commensurate with its name, and to compare favorably in beauty and attractiveness with any of the public squares in the city. This should be done in honor of the illustrious and lamented Lincoln, after whom the square was named.

The other items submitted are the usual and necessary ones for the

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ordinary care and protection of the public buildings and grounds under my charge.

To give an idea of the amount of work done and labor employed during the year in improving the various reservations, I would state that there have been laid 46,000 square feet of sod, 3,456 feet of gas-pipes, 8,282 feet water-pipes, and 19,200 feet of drain-tile. To the water-pipes 22 street-washers have been attached. There have also been laid 19,285 feet of stone flagging, 1,000 feet of curb, 4,142 square yards of asphalt walks, and 1,160 square yards of brick pavement, and about 3,000 square yards of gravel walks have been taken up and relaid; to accomplish which 48,652 days' labor of men and 6,838 days' labor of horses and carts have been expended, and over 26,000 cubic yards of earth removed.

In the execution of the works under my charge, I have received the earnest, willing, efficient, and steady aid of my assistant, Mr. George D. Benjamin.

The experience and ability of Mr. George H. Brown as landscape-gardener and botanist have been of the greatest assistance during the year.

In the office, Mr. F. A. Edwards, my clerk, has been continually efficient and attentive.

The experience, in plumbing and gas-fitting, of Mr. W. H. Bailey, together with his untiring application, has been of great value to the Department.

Accompanying this report is a detailed estimate of the funds required for the fiscal year ending June 30, 1874.

WASHINGTON AQUEDUCT.

District of Columbia 36-inch main.—On the 8th day of September, 1871, a contract was made with Messrs. Jesse W. Starr & Sons for furnishing all the pipes and special castings required for the District of Columbia 36-inch main. The first shipment, containing 103 pipes, was received November 13. Other shipments followed in rapid succession, until the close of navigation, and the final shipment was received on the 13th of last April. All the pipe and castings furnished by Messrs. Starr & Sons was of excellent quality, and in every respect fulfilling the requirements of their contract.

A contract was made on the 25th of August, 1871, with Theodore T. Woodruff, esq., proprietor of the Norris Iron-Works, Philadelphia, for furnishing and delivering the stop-cocks, and all were received within the time specified for their delivery.

On the 21st of September, contracts were made for laying the pipes. To Messrs. Emmart, Dunbar & Smith, of Washington, were awarded the reservoir, the East and the West Washington divisions; and to Messrs. O'Hare, Himber & Company, the Georgetown division. The work was commenced in November, and continued rapidly and in a satisfactory manner on each division, except the Georgetown.

The contractors for this division suspended work in January, and in February notified this office that Mr. Davenport, a member of their firm, was empowered to carry on and complete the work. Under Mr. Davenport's management the work was resumed and prosecuted till its completion, the last 36-inch joint being leaded and calked on the 18th day of June.

On the reservoir, the East and the West Washington divisions, the work was rapidly prosecuted during the winter and spring, and on the 5th

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day of June the Potomac water was shut off from the cities of Georgetown and Washington, in order to connect the District of Columbia 36-inch main with the Washington aqueduct 30-inch main at Foundery Branch. The water remained off for forty-nine hours, during which a section of the 30-inch main was taken out and a T-branch with 30-inch stop-valve set in place. The connection with the 36-inch main was not fully completed until the 1st of July; on the 2d the water was turned into the new main from Foundery Branch to Rock Creek; on the 3d the 36-inch main in L street was filled from Rock Creek to Eleventh street west, and the people residing on the high ground north of K street and west of the Capitol, received an abundant supply of Potomac water. The 36-inch main is now laid from the distributing-reservoir to the end of the route at the intersection of L street and New Jersey avenue. The East Washington division was filled August 5, and the reservoir division on August 6. Throughout the entire line, a distance of 22,000 feet, not a leak has occurred, which shows that the making of the joints has been faithfully performed. There remains but one connection to be made, that with the Washington aqueduct 30-inch auxiliary-pipe line. With this exception the entire line is finished. The distributing-reservoir has been filled with Potomac water, and the final connection is now being made.

District of Columbia 30 and 20 inch mains.—On the 21st of February a contract was made with Jesse W. Starr & Sons to furnish 30 and 20 inch pipes and special castings. All the pipes and castings called for were delivered before the 1st of May, the date specified in the contract for its completion.

On the 23d of March a contract was made with Robert Strong & Co. for laying District of Columbia 30 and 20 inch. All the pipes have been hauled and distributed, and a number of the 30-inch pipes have been laid in New Jersey avenue. The work has not progressed with sufficient rapidity, as according to the terms of the contract it should have been fully completed by the 1st of June. The contractors were notified to increase their force, and their attention was called to the penalty expressed in their contract, which provides that the contractors shall forfeit $1 a day, for each and every day's delay in the laying of each and every pipe and special casting. At the present time the District of Columbia 30-inch main is finished, with the exception of the connection to be made with the United States 30-inch main in New Jersey avenue, and which is now being done.

The pipe-line of the Washington Aqueduct.—The pipe-line is in good condition, and very few leaks have occurred. The 20-inch pipe in Maine avenue, the 12-inch pipe in Pennsylvania avenue east of the Capitol, the 12-inch pipe in Eighth street northwest, and the 12-inch pipe in Bridge street, Georgetown, have been lowered from 3 to 4 feet, in consequence of the grades of the streets being changed. The lowering was successfully accomplished without shutting off the water, under the supervision of the water-registrar, and the expense was paid by him from the corporation water-fund.

The quantity of water supplied during the past year has averaged over 12,000,000 gallons daily, the greatest consumption being in the winter, when many consumers allow their pipes continually to waste to prevent freezing. The attention of Congress having been called to this subject, a law was passed, and approved July 14, 1870, from which the following is extracted:

That in order to prevent unnecessary waste of Potomac water, and in order to more fully enforce the laws of the corporations of Washington and Georgetown, in relation

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to the distribution of the same, the engineer officer in charge of the Washington Aqueduct is hereby authorized and empowered, after giving notice, to shut off the water, when such notice shall be disregarded, from any places where a waste of water is occurring.

In December last the consumption and waste had become so great as materially to reduce the pressure in the Government mains, and the consumers in both cities were duly notified to stop all waste. The notice was disregarded, and a watchman was employed who daily reported the localities where waste was detected, and the same being reported to the water-registrar, the parties offending were fined and deprived of water.

Office of the Washington Aqueduct.—The contract for building an office for the Washington Aqueduct was let to the lowest bidders, William B. Downing & Brother, who have made good progress toward its completion.

High-service reservoir.—The contract for furnishing and setting an ornamental iron cornice on the dome of the reservoir, and building a wrought-iron fence around a portion of the grounds, was awarded to John W. Pearce, esq. All the iron work has been delivered and set in place, and is now being painted and gilded. The old plaster on the exterior of this reservoir has been removed, the dome has been covered with pebble-stucco, and the reservoir, as now finished, is an ornament to that part of Georgetown.

The entire iron work, according to the terms of the contract, should have been finished last November.

The water-pressure engine and the steam-pump that supply this reservoir with Potomac water have been kept in constant operation. The building of an office at Rock Creek necessitates the removal of the steam-pump and boiler from their present location, and the Board of Public Works has been requested to remove them to a higher locality. The steam-pump can be placed from 75 to 80 feet higher, and the saving in the cost of pumping would in a few years fully repay the cost of a lot, together with the expense of removing the pump and erecting a brick building in which to place it.

The consumption of Potomac water on Georgetown Heights is constantly increasing, and as it has to be supplied by pumping-machinery, a 36-inch branch with 12-inch outlet was placed in the District of Columbia 36-inch main at the intersection of High and Bridge streets. A 12-inch main should be laid from this point up High street to a point near the dividing line of the "high and low services," and a "Worthington duplex steam-pump" (or some other equally as good) should be erected. The present steam-pump, a "Knowles and Sibley," was erected in March, 1871, and was located in its present position because the corporation of Georgetown had no lot on which it could be placed.

Distributing-reservoir.—The influent and effluent gate-houses and the stair-well house have been finished. The slope wall is built entirely around the reservoir from the bottom to the top of the embankments, with the exception of a small portion to be built on the slopes of the dividing bank, adjoining the central gate-house, and which cannot be done till the gate-house is finished.

Plans, specifications, and form of contract were made, and advertisements were issued inviting proposals for building the central gate-house. The contract was awarded to the lowest bidders, Messrs. Lee & Doherty. The only work these contractors did was the excavations for foundations. On the 7th of February they were duly notified that if satisfactory progress was not being made with the work by the 1st of March

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their contract would be annulled. No attention was paid by the this notice, and consequently on the 2d of March their contract was annulled, and the money which they had deposited with the Treasurer of the United States to the credit of the Washington Aqueduct, as a guarantee that they would complete the work before the 1st of January, 1872, was forfeited to the United States as liquidated damages. On the 8th of March responsible contractors were invited to bid for the construction and completion of this work, and the contract was awarded to the lowest bidder, T. A. McLaughlin, esq., of Washington. The work was soon after commenced, and is progressing in a satisfactory manner.

An appropriation was made by Congress during the last session for furnishing and laying a 48-inch cast-iron pipe from the central gate-house to the effluent-well house, also for excavating a portion of the bottom of the reservoir.

Plans and specifications were prepared, and contracts for the work were awarded, after advertisement, to the lowest bidders, as follows: For furnishing 48-inch pipes, to Messrs. Jesse W. Starr & Sons, of Camden, New Jersey. For laying 48-inch pipe, and excavating the bottom of the reservoir, to Messrs. Emmart & Smith, of Washington. The work will be commenced soon, and completed before the end of the present year.

The existing appropriations are sufficient to complete this reservoir, and the structures pertaining to it, except the fence, for which there is an appropriation of $3,600. A contract has been made with A. H. Coon, esq., for building a wooden fence around this reservoir, and the high-service reservoir in Georgetown. The length of fence to be built at the high-service reservoir is 316 feet, and at the distributing-reservoir 5,874 feet. The appropriation is only sufficient to build (at the contract price) 4,816 feet, leaving a balance of 1,374 feet.

A gate-keeper will always be required for regulating the flow of water. The cabin in which he now lives is small and uncomfortable, being simply a common "shanty." A new house should be constructed of a style commensurate with the other structures at this reservoir.

As recommended in previous reports, the bottom of the distributing-reservoir should, in my opinion, be excavated to the level of the iron mains leading from it, or a maximum depth of 13 feet. The expense of deepening would be about $200,000. With the completion of the dividing bank and the central gate-chamber, together with the 48-inch pipe, the reservoir will be divided into two divisions, either of which can be used for the storage of water while the other is empty and being deepened.

Receiving-reservoir.—The work remaining to be done at the receiving-reservoir is to construct wing-walls at the upper connecting of the connecting-conduit, and to complete the protection of the slopes with rip-raps. There is a balance of an appropriation available for this purpose, but the work cannot be done well without emptying the reservoir, and it is not advisable to do this until the completion of the distributing-reservoir.

Stone bridges.—A contract was made with the lowest bidders, Messrs. Lee, Palmer & Co., for furnishing and setting coping for the parapets of Cabin John bridge, the work to be fully completed by the 1st of March, 1872. The contractors were duly notified to begin their work, but it appearing on the 1st of March that they had not made a commencement, they were in consequence notified that their contract was annulled, and the money they had deposited with the Treasurer of the

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United States, to the credit of the Washington Aqueduct, was forfeited as liquidated damages.

On the 8th of March proposals were again invited for this work, and a contract was made with Mr. Jacob Muddaman, of Alexandria, Virginia. Mr. Muddaman did not deliver any materials at the site of the work till the beginning of May, when he delivered about 200 running feet of cut-stone coping. An inspection of the stones delivered showed that they were inferior, both in quality and workmanship, and entirely unfit for the purpose; they were consequently condemned.

As no further effort was made by Mr. Muddaman toward complying with the terms of his contract, the appropriation available for this work was expended in the purchase of stone of a good quality.

A further appropriation having been made by Congress in June last, the work has again been advertised, and let to the lowest responsible bidders, Messrs. R. A. Shinn & Co., of Georgetown.

The quantity of cut stone required for Cabin John bridge is 6,950 cubic feet, and for Griffith Park bridge, 3,106 cubic feet. The cost of completing these two bridges will be, at the prices of the present contracts, $28,963. The appropriation therefor is $23,782, requiring for their completion an additional appropriation of $5,181. To this must be added the amount required to complete the coping of bridges Nos. 1 and 2, which, at the contract prices, will amount to $3,422, making the total amount yet required for finishing stone bridges, $8,603.

Roads.—The macadamizing of the roadway over the conduit was suspended in November. The work was resumed in February and continued until the balance of the appropriation was expended. The conduit-road is now macadamized from the distributing-reservoir to Griffith Park bridge, a distance of six and three-fourths miles. The rest of the road from this bridge to Great Falls, along the line of the aqueduct, a distance of five and one-third miles, should also be macadamized, and the embankment widened.

Potomac River and Dam.—The work of removing obstructions from the Maryland Channel of the Potomac River, above the Potomac Dam, was suspended in October, and resumed in May. Since the beginning of June the water has been very low, so low that the Maryland Channel has not furnished to the conduit as much water as is used in the two cities, the deficiency being supplied from the receiving-reservoir. As soon as it was ascertained that the water stored in the receiving-reservoir was being diminished, temporary dams were constructed in the Maryland Channel of the Potomac, at the upper end of Conn's Island, a distance of 3,500 feet above the Washington Aqueduct stone dam. (At this point Conn's Island divides the river into two channels, the Maryland and the Virginia, and during the stages of low water the greater part of the Potomac flows through the Virginia Channel.) The temporary dams diverted sufficient water from the Virginia Channel to make up the deficiency, and they will probably continue to do so until the fall rains raise the water in the river. These dams are built of brush, earth, and stones, and will be washed away in the spring freshets. The consumption of water in Georgetown and Washington is yearly increasing, and at present may be considered equivalent to the minimum flow of the Maryland Channel. It is evident, therefore, that the present dam will not supply during the low stages of the river anything near the demand that will be made for water when the new mains, now nearly completed, are brought into operation, and connected with the distributing-pipes of the two cities, and in my opinion the stone dams should be constructed entirely across the river to the Virginia shore.

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The estimates for which appropriations should be made for the next fiscal year are as follows:

For finishing the wooden fence at the distributing-reservoir	$1,500 00
For dwelling for the gate-keeper	2,500 00
For completing stone bridges	8,600 00
For completing the macadamizing of the conduit-road	16,000 00
For engineering, maintenance, and general repairs	15,000 00
For continuing the cut-stone dam across the Virginia Channel of the Potomac River	100,000 00
	143,600 00

The following is a financial statement for the last fiscal year, ending June 30, 1872:

Titles of appropriations.	Available July 1, 1871.	Expended in 1871-'72.	Available July 1, 1872.
ACT OF JULY 15, 1870.			
(1.) Purchase of roadway from Great Falls to conduit-road	$791 00	$504 78	$286 22
(2.) Purchase of roadway across land of William Brooks	550 00	342 55	207 45
(3.) Clearing out obstructions above dam near head of aqueduct	2,599 87	1,857 86	742 01
(4.) Repairs in tunnel No. 1, and removing fallen stone	1,162 40		1,162 40
(5.) Preserving new or Dalecarlia Tunnel	2,404 84		2,404 84
(6.) Slope wall of distributing-reservoir	25,482 33	24,337 85	1,144 48
Completing gate-house at distributing-reservoir	18,591 60	18,591 60	
Completing arch at high-service reservoir	3,870 00	3,870 00	
ACT OF MARCH 3, 1871.			
Engineering, superintendence, and repairs	20,000 00	20,000 00	
Earthwork and slope wall of division-dam	20,000 00	5,010 62	14,989 38
Slope-wall of distributing-reservoir	20,000 00	20,000 00	
Completing gate-houses at distributing-reservoir	20,496 00	10,497 40	9,998 60
Finishing coping and iron railing on bridges Nos. 1, 2, 3, and 4	10,000 00	10,000 00	
Macadamizing conduit-road	10,000 00	10,000 00	
Completing high-service reservoir	4,000 00	1,970 38	2,029 62
Fencing reservoirs	3,600 00		3,600 00
Building office at Rock Creek bridge	3,300 00	18 00	3,282 00
Ventilators over conduit	2,800 00		2,800 00

Of the above balances of the act of July 15, 1870, Nos. 1 and 2 have reverted to the United States Treasury. Nos. 3 and 6 were expended last month. Nos. 4 and 5 cannot be expended to advantage until the completion of the distributing-reservoir, which, when filled, will afford sufficient storage capacity so that the conduit and receiving-reservoirs can be emptied out when the work in Tunnel No. 1 and at Dalecarlia tunnel will be completed.

I have received at all times the fullest assistance from my assistant engineer, Mr. Theodore B. Samo, whose ability as civil engineer, and full personal knowledge of the Washington Aqueduct, have rendered his services most valuable.

Mr. R. D. Dunning, the clerk for the Washington Aqueduct, has rendered untiring, faithful services.

Very respectfully, your obedient servant,

O. E. BABCOCK,
Major of Engineers, United States Army,
In charge Public Buildings and Grounds.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, United States Army.

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Y 1.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS,
CORNER PENNSYLVANIA AVENUE AND TWENTY-FIRST STREET,
Washington, D. C., May 14, 1872.

In answer to House resolution of the 8th ultimo, I have the honor to submit herewith a tabular statement giving the description, area, and condition of the Smithsonian, agricultural, monumental, and the grounds around and between the President's House and the canal, together with the area and condition of all other public reservations in this city under my charge.

I also have the honor to submit the following statements showing the amount of expenditures necessary to put the grounds around the Washington Monument; between the President's House and the canal; the Smithsonian grounds; the grounds known as Armory Square; the reservations between Sixth and Third streets and south of the canal, in good condition, as follows: For grading, draining, and subsoiling; introducing water; constructing, grading, graveling, and rolling walks and roads; purchasing trees, plants, shrubs, grass-seed, &c., and planting and sowing, as per detailed statements following, viz:

Monumental grounds.

15,000 cubic yards of grading, at 30 cents	$4,500
10,000 feet two-inch drain-tile, at $30 per thousand	300
2,000 feet four-inch drain-tile, at $65 per thousand	130
Labor laying the same	570
800 feet four-inch water-pipe, at 70 cents	560
3,000 feet two-inch water-pipe, at 40 cents	1,200
12 street-washers, at $20	240
25,112 square yards of roads and walks, to be graded, graveled, and rolled, at $1.50	37,668
Trees, plants, shrubs, and grass-seed, and labor planting the same	2,000
	47,168

This statement does not include any estimate for filling the marsh in the monumental grounds west of the road already built to the canal.

For the grounds between the President's House and the canal, it is estimated will require 82,800 cubic yards of earth to fill to the grade as now established by the Board of Public Works on Fifteenth and Seventeenth streets, at a cost of thirty cents per cubic yard, making a total of $24,840. Several thousand cubic yards of earth will be deposited on these grounds during the season, from excavations to be made for the new State Department, without expense to this office. In estimating for the improvement of these grounds for the next fiscal year, an appropriation of $10,000 was asked for the purpose of grading, and purchasing such earth as can be bought from the different contractors and others in the city at fair prices. This amount, I think, is all that can be judiciously expended during the coming fiscal year. I have not deemed it advisable to have any plans prepared for the improvement of these grounds until such time as they shall be entirely filled and graded, in consequence of which no detailed statement for their improvement can be estimated.

Smithsonian Grounds.

For sub-drainage	$2,600
For grading	600
Constructing walks and roads	17,000
Surface drain	1,800

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Smithsonian Grounds—Continued.

Water-pipes, and laying the same, for irrigation and drinking purposes	$2.00
Trees, shrubs, &c	[illegible]
Regraveling and grading walks north of the Institute	4,00
	[illegible]

Armory Square.

Grading	[illegible]
Sub-drainage	[illegible]
Water for drinking and irrigation	1,[illegible]
Trees, shrubs, &c	[illegible]
Graveling and making 5,600 square yards of walks and roads, at $1.50	[illegible]
	11,[illegible]

Reservation between Third and Sixth streets and south of the canal.

Grading	$1,29[illegible]
Grading and making walks	12,9[illegible]
Sub-drainage	3,[illegible]
Introducing water	2,00
To fill, to grade, and for purchase of trees, plants, &c	4,47[illegible]
	24,62[illegible]

In making the above estimate it has been my intention to give such estimates only as it is believed will place the grounds in good condition. I have not included the expense of ornamenting, nor for the purchase of fences, which most of these reservations will soon require.

Very respectfully,

O. E. BABCOCK,
Major of Engineers, United States Army,
In charge Public Buildings and Grounds.

To the HOUSE OF REPRESENTATIVES.

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Description and area of lands occupied by the Washington Aqueduct, under the charge of O. E. Babcock, Major of Engineers, United States Army.

Description.	AREA.		Remarks.
	Acres.	Square feet.	
Beginning at the head of the aqueduct on the Virginia shore.	5	26,780	Purchased as a site for a bulk-head in the event of the dam being built entirely across the Potomac.
At the head of the aqueduct on the Maryland shore.	4	32,670	Used for office and other necessary buildings during the construction of the works.
From the Great Falls to the receiving-reservoir—10 miles.	120	.....	The conduit of the Washington Aqueduct follows the sinuosities of the Potomac River, and the land varies in width from 100 to 200 feet, occupied by aqueduct and road.
From Great Falls, following the present road to its junction with the conduit-road—2½ miles.	7	10,890	The total number of acres occupied by this road is 17½; the remaining 10½ acres are yet to be purchased. This road was built in order to reach the Potomac Dam, it being found impracticable to construct a road over this portion of the country, along the route of the conduit.
The receiving-reservoir*	281	32,670	This reservoir is located on a tract of land called the "Dalecarlia." As the reservoir is located near the middle of the tract, the United States bought and now own the entire tract. The reservoir occupies about sixty acres. The remainder is occupied by the Reform School of the District of Columbia and gate-house connecting conduit and road. 120 acres of this can be cultivated without injury to the water of the reservoir; the remainder should not be, as the land slopes toward the water.
From the receiving-reservoir to the distributing-reservoir.	24	.....	The Government owns a strip of land along this route, of various widths, a distance of 2½ miles, and is occupied by the conduit and road.
Distributing-reservoir	60	.....	But 44 acres of this is of water surface.
From the distributing-reservoir to Georgetown.	3	26,780	This ground, about 40 feet wide, is occupied by the United States 30 and 12 inch water-mains, and the new District of Columbia 36-inch main.
High-service reservoir and office at Rock Creek bridge.	3	32,678	Occupied as high-service reservoir for the distribution of water in Georgetown, and for office at Rock Creek bridge.
Total	510	26,780	

OFFICE OF WASHINGTON AQUEDUCT, *Washington, D. C.*, 1872.

O. E. BABCOCK,
Major of Engineers, United States Army, in charge.

Description, area, and condition of Government reservations in the city of Washington, D. C., under the charge of O. E. Babcock, Major of Engineers, United States Army.

Description.	AREA.		Present condition and remarks.
	Acres.	Square feet.	
Smithsonian grounds	52	24,072	The grounds north of the Institute graded, laid out in roads and walks, and planted in accordance with the plans of Downing; the portion south of the Institute not graded nor planted. The grounds are inclosed with a very cheap wooden fence, which is nearly worthless.
Monumental grounds	44	40,149	These grounds are in very bad condition, a portion overflowed at high tide, the rest ungraded, without drains, roads, walks, trees, or shrubbery.

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Description, area, and condition of Government reservations, &c.—Continued.

Description.	AREA.		Present condition and remarks.
	Acres.	Square feet.	
President's grounds	80	31, 991	The north half of these grounds is improved, well lighted, and inclosed in the greater part with substantial iron fences, and surrounded with stone walks, interspersed with choice trees and evergreens, well drained, and a plentiful supply of water, making them in good condition. The south half unimproved, and being filled to grade, as established by Board of Public Works on Fifteenth and Seventeenth streets.
Capitol grounds	48	30, 261	The inclosed portion in good condition. The improvement of these grounds not under the charge of this office.
Reservation between Third and Four-and-a-half streets, Missouri avenue.	2	1, 055	Inclosed with a wooden fence, used as a propagating garden, and in good condition.
Reservation between Third and Four-and-a-half streets, Maine avenue.	2	2, 847	Inclosed with a wooden fence, unimproved and without roads, walks, or improvements of any kind.
Reservation between Four-and-a-half and Seventh streets, south of canal.	17	10, 818	Inclosed with a wooden fence, without walks, roads, or drainage, with some trees and shrubbery.
Reservation No. 17, at the convergence of New Jersey, South Carolina, and North Carolina avenues.	23	24, 311	Vacant and unimproved; formerly selected as a site for the new jail.
Judiciary Square	19	8, 734	South portion in good condition, and surrounded with iron fence; middle and western portion occupied by jail, and buildings donated to the use of the Women's Christian Association. This portion of the grounds in poor condition, not graded, drained, planted, nor laid out in roads and walks.
Franklin Square	4	178	Surrounded with brick pavement; gas around the square; inclosed with a substantial iron fence; thoroughly sub-drained; walks laid out and graveled, and in good condition and planted with a collection of trees and shrubs.
La Fayette Square	6	43, 334	Surrounded with brick pavement; gas in and around the square; inclosed with a substantial iron fence; thoroughly sub-drained, walks laid out and graveled, and in good condition, and planted with a collection of trees and shrubs; also watchman's lodge, with urinals for both sexes.
Circle at the intersection of New Hampshire and Pennsylvania avenues.	.....	20, 214	Inclosed with an iron fence; walks laid out, but not very well graveled; surrounded by a brick pavement.
Circle at the intersection of New Hampshire, Connecticut, and Massachusetts avenues.	.....	20, 528	Inclosed with a poor wooden fence and graded, no walks laid out; no trees or shrubs; not surrounded by pavement; no drainage or water.
Circle at the intersection of Massachusetts and Vermont avenues.	.....	6, 363	Inclosed with an iron fence, and being thoroughly improved by grading, sodding, making walks, putting in fountain, and planting trees and shrubs.
Circle at the intersection of Rhode Island and Vermont avenues.	.....	20, 114	Vacant and unimproved.
Semicircle at the eastern terminus of Pennsylvania avenue.	4	33, 248	Do.
Scott Square, on Vermont avenue	1	6, 210	Now being improved by making and grading walks, inclosing with iron posts and chain and introducing water for irrigation and drinking; lighted.
Farragut Square, on Connecticut avenue.	1	5, 265	Inclosed with picket-fence; unimproved.
Reservation at the intersection of Rhode Island and Massachusetts avenues.	1	4, 240	Vacant and unimproved.
Reservation at the intersection of Massachusetts and Maryland avenues, (Stanton Place.)	3	10, 760	Do.
Lincoln Square	6	12, 161	Inclosed with a picket-fence, and partly improved.
Reservation on New York avenue, between Eighteenth and Nineteenth streets.	1	11, 514	Vacant and unimproved.
Reservation at intersection of Massachusetts and New York avenues.	.....	40, 945	Inclosed with a picket-fence, and improved.

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Description, area, and condition of Government reservations, &c.—Continued.

Description.	AREA.		Present condition and remarks.
	Acres.	Square feet.	
Reservation at intersection of Pennsylvania and North Carolina avenues.	3	9,765	Vacant and unimproved.
Reservation at intersection of Pennsylvania and South Carolina avenues.	2	8,348	Do.
Reservation on North Carolina avenue, between Second and Third streets east.	1	21,516	Do.
Square No. 1113.	3	3,537	Vacant.
Reservation at intersection of Ohio and Louisiana avenues.	.....	26,166	Vacant and unimproved.
Reservation on Maryland avenue and Second street west.	.....	24,619	Do.
Triangular reservation—			
New Hampshire avenue and Seventeenth street west.	.....	2,833	Do.
New Hampshire avenue and Twenty-fifth street west.	.....	2,237	Do.
New Hampshire avenue and Twenty-sixth street west.	.....	2,237	Do.
Vermont avenue and Tenth street west.	.....	3,129	Do.
Vermont avenue and Thirteenth street west.	.....	908	Do.
Massachusetts avenue and Sixth street west.	.....	4,378	Do.
Massachusetts avenue and Tenth street west.	.....	4,097	Inclosed with a picket-fence and not improved.
Massachusetts av. and Twelfth street west.	.....	3,678	Do.
Massachusetts avenue and Seventeenth street east.	.....	3,538	Vacant and unimproved.
Massachusetts avenue and Twentieth street west.	.....	1,029	Do.
Connecticut avenue and Twentieth street west.	.....	819	Do.
Rhode Island avenue and Ninth street west.	.....	2,154	Do.
Rhode Island avenue and Twelfth street west.	.....	4,050	Do.
New York avenue and First street west.	.....	9,350	Do.
New York avenue and Sixth street west.	.....	6,448	Do.
New York avenue and Tenth street west.	.....	7,429	Inclosed with a picket-fence and not improved.
New York avenue and Twelfth street west.	.....	7,330	Do.
New York avenue and Thirteenth street west.	.....	1,625	Do.
Pennsylvania avenue and Seventh street west.	.....	8,881	Inclosed with an iron fence and partly improved.
Pennsylvania avenue and Thirteenth street west.	.....	12,687	Do.
Pennsylvania avenue and Fourteenth street west.	.....	12,828	Do.
Pennsylvania avenue and Eighteenth street west.	.....	8,889	Inclosed with a picket-fence and partly improved.
Pennsylvania avenue and Nineteenth street west.	.....	8,906	Do.
Pennsylvania avenue and Twentieth street west.	.....	9,506	Inclosed with an iron fence and partly improved.
Pennsylvania avenue and Twenty-first street west.	.....	8,596	Inclosed with a picket-fence and partly improved.
Pennsylvania avenue and Tenth street east.	.....	881	Vacant and unimproved.
Pennsylvania avenue and Twelfth street east.	.....	2,243	Do.
New Jersey avenue and Second street east.	.....	3,349	Do.
Delaware avenue and Second street west.	.....	6,672	Do.
Delaware avenue and First street east.	.....	3,980	Do.
Delaware avenue and First street east.	.....	2,870	Do.
Maryland avenue and Third street west.	.....	6,284	Do.

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Description, area, and condition of Government reservations, &c.—Continued.

Description.	AREA.		Present condition and remarks.
	Acres.	Square feet.	
Triangular reservation—			
Maryland avenue and Third street east.	.....	1,500	Vacant and unimproved.
Virginia avenue and Four-and-a-half street west.	.....	2,838	Do.
Virginia avenue and Eighteenth street west.	.....	1,082	Do.
Virginia avenue and Twenty-fourth street west.	.....	468	Do.
Virginia avenue and Twenty-fourth street west.	.....	468	Do.
Virginia avenue and Twenty-fifth street west.	.....	1,171	Do.
Virginia avenue and Fourth street east.	.....	2,207	Do.
Virginia avenue and Ninth street east.	.....	3,078	Do.
Virginia avenue and Twelfth street east.	.....	8,214	Do.
South Carolina avenue and Fourth street east.	.....	4,305	Do.
South Carolina avenue and Sixth street east.	.....	3,619	Do.
Georgia avenue and Half street west.	.....	6,457	Do.
Georgia avenue and Half street west.	.....	4,932	Do.
Georgia avenue and Second street west.	.....	4,014	Do.
Georgia avenue and Second street west.	.....	4,690	Do.
Georgia avenue and Half street east.	.....	5,997	Do.
Georgia avenue and Half street east.	.....	7,076	Do.
Georgia avenue and Ninth street east.	.....	1,763	Do.
Georgia avenue and Eleventh street east.	.....	1,371	Do.
Georgia avenue and Seventeenth street east.	.....	2,433	Do.
Water street and Half street west.	.....	5,286	Do.
Water street and Fourteenth street east.	.....	2,187	Do.
Water street and Fifteenth street east.	.....	1,250	Do.
South Capitol street and E street south.	.....	1,200	Do.
South Capitol street and I street south.	.....	6,533	Do.
First street west and D street south.	.....	2,854	Do.
First street west and L street south.	.....	4,275	Do.
First street west and N street south.	.....	2,301	Do.
Sixth street west and N street south.	.....	1,656	Do.
Total	340	1,489	
Agricultural grounds.....	33	40,792	Not under the charge of this office
Washington Aqueduct.....	510	21,780	

O. E. BABCOCK
Major of Engineers, United States Army.

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APPENDIX Z.

ANNUAL REPORT OF MAJOR C. B. COMSTOCK, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1872.

SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

LAKE SURVEY OFFICE,
Detroit, Michigan, July 1, 1872.

GENERAL: In compliance with circular of June 13, 1872, I have the honor to submit the annual report of the Survey of the Northern and Northwestern Lakes for the fiscal year ending June 30, 1872.

As my last annual report was dated October 4, 1871, at which time the summer's field-work had nearly closed, and as the balance of the appropriation on hand this spring was not sufficient to justify the fitting out of parties until the passage of the new appropriation was certain, so that the parties for this year have but just started for the field, there is little additional field-work to report.

LAKE SUPERIOR.

Since my last annual report the remeasurement of the angles in the vicinity of Keweenaw base has been completed, and on October 17, 1871, the parties returned to Detroit.

On June 28, 1872, Assistant G. Y. Wisner, in charge of the steamer Surveyor, and, with the parties of Assistant G. A. Marr and Sub-Assistant R. S. Woodward, started for Lake Superior with instructions to connect the triangulation in Lake Superior, near Marquette, with that in Green Bay. It is hoped that they may complete this work this summer.

LAKE MICHIGAN.

Owing to the extensive fires on both shores of Lake Michigan, the azimuth parties of Lieutenants Lee and Weeden accomplished little or no work subsequent to the date of my last report and both were withdrawn from the field, reaching Detroit by October 25. The shore parties of Assistants Mayer, Foote, and Custer were withdrawn from Lake Michigan about the date of my last report. The hydrographic party of Lieutenant Lee, with the steamer Search, the astronomical parties of Lieutenants Maguire and Powell, to carry lines of azimuths and latitudes down the two shores of Lake Michigan, and the shore parties of Assistants Mayer and Custer, are now fitting for the field, and will start in a few days for Lake Michigan. Should the weather be very favorable, it is hoped that the topography and hydrography of the lake may be completed by the parties named this season. The fires in October, 1871, interfered seriously with the measurement of the angles of the triangulation extending south from Green Bay, and, on November 9, Assistant E. S. Wheeler, who was employed on that duty, left the field. On June 27, 1872, Assistant E. S. Wheeler started for the field with instructions to make a reconnaissance for a primary base-line in the vicinity of Lake Winnebago, Wisconsin. Should the reconnaissance be satisfactory, it is hoped to measure the base this fall.

On May 14, 1872, Assistant A. R. Flint commenced a reconnaissance

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for a system of triangles along the lake, from Racine to the south end of the lake. He has succeeded in finding satisfactory stations as far south as Chicago, and has now been sent to Green Bay to read the angles of the triangulation running south from that point.

SAINT LAWRENCE RIVER.

The parties on the Saint Lawrence were all withdrawn by November 7, 1871, the topography and nearly all of the hydrography having been by that time completed from the forty-fifth parallel to Brockville. On June 22, 1872, the steamer Ada, under command of Lieutenant W. R. Livermore, with the shore parties of Assistants Lamson and Towar, and the triangulation party of Assistant Foote, started for the Saint Lawrence to continue the work toward Lake Ontario.

In compliance with instructions from the Chief of Engineers, a resurvey of Sandusky Harbor was made by Assistant A. C. Lamson, in May and June, 1872. The work has not yet been plotted. In June Lieutenant Lee was directed to observe for magnetic elements at several points on the lakes. His work has not yet been reduced.

OFFICE.

During the winter Lieutenants Maguire and Powell, and Assistants Lamson, Custer, Mayer, Foote, and Towar plotted their summer's field work on thirty-five sheets of antiquarian paper, giving a large amount of detailed topography and hydrography, and covering a developed shore-line in Lake Saint Clair of eighty-three miles; in Lake Michigan, of two hundred and sixty-three miles; on the Saint Lawrence River, of two hundred and seventy-nine miles; and on Lake Champlain, of thirty one miles.

The reduction of their summer's astronomical work by Assistants O. B. Wheeler, G. Y. Wisner, A. R. Flint, and G. A. Marr, has been nearly completed. The chronograph-sheets have been read off, and the clock-errors and rates determined for the longitude work between Detroit and the party under Lieutenant G. M. Wheeler at Austin and Battle Mountain, Nevada, and the results have been furnished to Lieutenant Wheeler.

The longitude work between Detroit, Duluth, and Saint Paul has been reduced, and results are given in Appendix G.

Results for difference of longitude by powder-flashes in Lake Superior are given in Appendix H.

At the date of forwarding my last annual report, the final clock-corrections and rates of Washington clock for our longitude work in connection with the Naval Observatory at Washington had not been received. They have since been sent to me by Admiral B. F. Sands, Superintendent Naval Observatory, and are given in Appendix F.

The Signal-Service having established meteorological stations at or near many of the places occupied by the Lake Survey, and the Chief Signal-Officer having courteously directed that copies of the Signal-Service observations at those points should be furnished to the Lake Survey, the Chief of Engineers authorized the suspension of meteorological observations by the Lake Survey at those points. Accordingly, meteorological observations are now made only at Port Austin, Detroit and Monroe, Michigan; Erie, Pennsylvania, and Sackett's Harbor, New York. Self-registering tide-gauges are in operation at Chicago, Illinois; Milwaukee, Wisconsin; Duluth, Minnesota; Port Austin,

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Michigan; and staff-gauges at Detroit, Michigan; Cleveland, Ohio; Erie, Pennsylvania; Charlotte, New York; Sackett's Harbor, New York. The meteorological reductions during the past year have been in charge of Assistant O. B. Wheeler, whose report is given in Appendix K.

Assistant O. B. Wheeler has also had charge of the revision of computations, and a *résumé* of the work done will be found in Appendix L, containing reports of chiefs of parties.

Mr. Molitor has completed for the engraver the final chart of Isle Royale, on a scale of $\frac{1}{120000}$, and of Saint Clair River on a scale of $\frac{1}{40000}$. Mr. Mueller has completed the final Chart No. 1 of Lake Superior, and has the last Sheet No. 3 well advanced, both on a scale of $\frac{1}{400000}$.

Last fall the five new Lake Survey Standard Yards in process of construction at the Office of Weights and Measures, Washington, having been completed, I visited Washington for the purpose of comparing them with the new end-measure yards just constructed at that office, and now called Transfer Yards A and B. A description of the yards, and the preliminary results of comparison, are given in Appendix D. I am much indebted to J. E. Hilgard, esq., assistant in charge, for facilities afforded in the comparisons, and for having undertaken the construction of the new Lake Survey yards.

On April 29, 1871, an examination of the tides of the Great Lakes was directed by the Chief of Engineers. Accordingly, this question was taken up during the past winter for the station Milwaukee, that being a point at which there were available the records during the warmer portion of the year of a self-registering tide-gauge for several years. The heights of the water for solar hours were read off and tabulated for the entire lunations of which we had record, from 1867 to 1871, inclusive, and for lunar hours for the complete lunations in 1867. On examining the solar hourly mean heights for the period covered by the record in each year, (or the curves plotted from them,) a solar semi-diurnal tide was apparent of about four-hundredths of a foot; the tide following the sun's upper transit being considerably the larger. The known existence of a lake breeze at Milwaukee during the summer months at once suggested itself as a cause for this inequality, and on comparing the solar diurnal curve for April and November, when the lake breeze should be weak, and that for July and August, when the lake breeze should be strongest, with that of the whole season, it was found that for the former months the inequality nearly disappears, while for the latter it is considerably increased, thus justifying the supposition that the lake breeze is the cause of the inequality.

The examination of the lunar hourly mean heights for each lunation in 1867 (or of the curves plotted from them) showed a still more marked lunar semi-diurnal tide, its amount being eight-hundredths of a foot.

Theory would indicate that the maximum luni-solar tide should occur at syzygies when the declination of both sun and moon is near zero.

An examination of a few such observed tides gives the luni-solar tide at such times as twelve-hundredths of a foot, but as, in order to eliminate irregular disturbances, three days about each syzygy were taken, this value is smaller than the true value on the day of syzygy. The details of the examination and the theory of these tides will be found in Appendix A.

The same letter directed an examination of the seiches or unusual oscillations which occur on the lakes. For a thorough examination of this subject, we should have, on some one of the lakes where they occur, a

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sufficient number of self-registering tide-gauges, to record any unusual disturbance of the lake's surface which extended over any considerable area, and self-registering barometers at so many points that no local barometric disturbance could occur without being recorded. Then, if every unusual oscillation was coincident with or followed at a short interval a barometric disturbance at some part of the lake, the conclusion might be safely drawn that the latter was the cause of the former. No such thorough data exist or can be hoped for; but from an examination of unusual oscillations at Milwaukee and Marquette, it is seen that as a rule these oscillations occur with a low barometer, and in many cases with stormy weather, and thus suggest that the oscillations originate in barometric disturbance.

In some cases these oscillations have occurred without atmospheric disturbance at the place of observation, and in these it may be supposed that they have been transmitted from some distant point where there was local disturbance of the barometer. The details of the discussion are given in Appendix B.

The triangulation connecting the bases on Minnesota Point and on Keweenaw Point having been completed, it was deemed advisable to adjust it by the method of least squares, in order to compare the two bases, and as the adjustment, from the nature of the triangulation, could be divided into two parts without any sacrifice of accuracy, neither part giving rise to an unmanageable number of equations of condition, it is proposed to carry out the adjustment of those parts rigidly. As many of the angles have been read with a repeating instrument, the method of directions has not been used.

That part of the adjustment depending on observations at each station has already been made by Assistants Wisner and Flint, and the general adjustment has been begun. The special method adopted is given in Appendix C.

The survey of Lakes Huron, Superior, and Michigan being now completed or nearly completed, data are furnished for an accurate map of almost the entire outline of the State of Michigan. The outline being fixed accurately, it is easy to determine the positions of a sufficient number of interior points to serve as the base of an accurate map.

The Governor of Michigan is anxious that this assistance should be rendered to the State Geological Survey now in progress, and I have included in the estimate for the next fiscal year an item for the work. Governor Baldwin's letter is given in Appendix I.

During the winter the comparison of the Lake Survey Yards Nos. 6, 7, 8, 9, 10, (placed end to end,) with the 15-feet brass bar of the survey was begun by Assistant E. S. Wheeler, but the comparisons are not yet completed.

A new 12-inch repeating theodolite, by Troughton & Simms, having been received, it was thought best to have it carefully examined. This was done by Assistant E. S. Wheeler, and the results which are given in Appendix E show that the instrument is an excellent one.

The reports of field-work done by the parties under Lieutenants Livermore, Lee, and Weeden, and Assistants Lamson, Mayer, Foote, Wisner, Flint, and Marr, will be found in Appendix L.

The following officers of engineers have been under my command during the past year: First Lieutenant W. R. Livermore, First Lieutenant A. N. Lee, First Lieutenent J. H. Weeden, relieved June 7, 1872, Second Lieutenant E. Maguire, Second Lieutenant C. F. Powell. To these officers and to the civil assistants I am generally indebted for patient and faithful work for the advancement of the survey, in several cases under

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umstances of great difficulty from natural obstacles, or from sick-
s produced by the unhealthy field in which they were compelled to
Accompanying this report are Appendices from A to L, inclusive.

Very respectfully, your obedient servant,

C. B. COMSTOCK,
Major of Engineers and Brevet Brigadier-General.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers.

APPENDIX A.

TIDES AT MILWAUKEE, WISCONSIN.

In the examination of the question of tides in Lake Michigan, the point taken was ilwaukee, as at that point only we had the record of a self-registering tide-gauge, ttending over several years. The results of observation will first be given, and then se results of theory.

1. RESULTS OF OBSERVATION.—1. *To obtain the solar diurnal water-level curve.*—For this urpose, in each of the years from 1867 to 1871, inclusive, the greatest number of com-lete consecutive lunations, for which the record was tolerably perfect, was selected, nd the means of the heights for every mean solar hour in the day taken. As the umber of lunations used in each year varied from five to eight, (the gauge being stopped he rest of the year by ice or accidents,) the lunar semi-diurnal tide, if it exists, would e pretty nearly eliminated from these means. The mean hourly heights for each ear, and their general mean for the five years, are given in the table of co-ordinates for Plate I.

Plate I (drawn of the same size as a printed octavo page, for convenience in printing) gives the resulting mean curves for each year, and finally a mean of them all.

From an examination of these curves, it will be seen that all indicate unmistakably a fluctuation in the surface of the lake, depending on the solar hour of the day. The mean of the yearly curves gives 1 p. m. as the hour of maximum height, and 1 a. m. as the time of a secondary maximum, the height above low water at the first being forty-five-thousandths (0.045) feet, and at the second thirty-six-thousandths (0.036) feet.

2. *To obtain the lunar diurnal water-level curve.*—For this purpose five complete luna-tions in 1867 were selected, the tide-gauge sheet was read off for lunar hours, taking the average height for fifteen minutes on each side of the exact hour, and the means of these readings taken in each lunation for each hour in the lunar day. These means and their general mean are given in the table of co-ordinates for Plate II. The resulting curve for each lunation is plotted on Plate II, and also the mean curve for the five luna-tions. The curve for each lunation shows unmistakably the dependence of the water-level on the lunar hour of the day, and the mean curve gives high water at 1 p. m., and at 0h. 12m. a. m., lunar time, the height above lowest water at the first being eight-hundredths (0.08) feet, and at the second high water the same.

f the tides indicated by the curves on Plates I and II actually exist and depend on th positions of the sun and moon, they should at syzygies reinforce each other to pro-duce spring tides, and at quadratures should partially neutralize each other, giving neap tides. Accordingly, the solar hourly mean heights for five days, about each con-junction and opposition observed in 1867 and 1868, were taken, and a general mean of all taken. The results are given in the table of co-ordinates for Plate III. Plate III gies these separate curves and the mean curve, the latter showing the average spring tid during the period of observation. If the solar and lunar semi-diurnal tides indi-cted on Plates I and II exist, they should at syzygies reinforce each other to give a tide nerly equal to their sum.

he lower full line, Plate III, gives the mean of the curves above it for oppositions an conjunctions of 1867. The broken line is the sum at like hours of the solar diurnal cuve for 1867, Plate I, and of the mean lunar diurnal curve for the same period, Plate II. This agreement of the two shows that the tide of syzygies is what it should be, if Plates I and II give the correct solar and lunar semi-diurnal tides. The average spring tid then, at Milwaukee is ninety-eight-thousandths (0.098) of a foot.

Treating the observed quadratures for 1867 in the same way as the syzygies, we have the results given in the table of co-ordinates for Plate IV. These numbers are plotted on Plate IV, and the mean curve is also plotted.

The full line below the mean curve is the mean of the observed quadratures for 1867. The broken line is obtained by subtracting at like hours the solar diurnal curve, Plate I, from the lunar diurnal curve, Plate II. Their general agreement shows that there is a neap-tide at quadratures, and of nearly the same dimension as should follow from the solar and lunar semi-diurnal tides shown on Plates I and II.

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Finally, an inspection of the close agreement of the curves for each year on Plate I, with the mean curve; of the curves for each lunation, on Plate II, with their mean; of the observed tides for syzygies and quadratures in 1867 represented by full lines with their computed values, shown by broken lines, as shown on Plates III and IV, can leave little doubt that there are measurable solar and lunar semi-diurnal tides at Milwaukee, the average value of the former being very approximately forty-thousandths (0.040) of a foot, and of the latter eighty-thousandths (0.080) of a foot.

The combination of the two at syzygies should give a tide of 0.12 of a foot. The observed tide is less than this, and less than the general mean, Plate III. The difference is probably due to the fact that, to eliminate irregularities, so long a period as five days about the syzygies was taken to obtain this observed tide.

2. THEORY.—The moon and sun undoubtedly cause tides in Lake Michigan, and for the purpose of a rough computation of what their amount should be, the equilibrium theory of tides may be adopted.

Consider the moon alone. Call the earth's mass and radius each unity, and the moon's mass $\frac{1}{81}$ and her distance from the earth 60. Her attraction for any mass on the earth's surface will generally be different from her attraction on the same mass at the earth's center; and if we take the difference of these forces, neglecting parallax, and suppose it applied to the mass at the surface, and in the direction of the moon, so far as the mass is related to the earth, we may afterward consider only this differential or relative force, entirely dropping the moon. For a point of the lake, for which the moon's zenith distance at any time is Z, the ratio of this relative force to that of gravity will be—

$$\frac{1}{81}\left[\frac{1}{(60-\cos Z)^2}-\frac{1}{(60)^2}\right]$$

and its maximum value for Z=0 is 0.000 000 1144. In other words, the maximum value of the force arising from the moon's attraction, which tends to displace, with reference to the earth's center, one pound placed on its surface, is about $\frac{1}{9000000}$ pound.

The above relative force, acting in the direction of the moon, may be resolved into a horizontal and vertical component in a vertical plane through the moon. The maximum value of the vertical component being as above $\frac{1}{9000000}$, and being directly opposed by gravity, its maximum effect, if Lake Michigan were 90° long, would be, taking it as 500 feet deep, to change the depth of the water by but $\frac{1}{18000}$ of a foot, and hence this vertical component can be entirely neglected. The horizontal component is—

$$\frac{1}{81}\left[\frac{1}{(60-\cos Z)^2}-\frac{1}{(60)^2}\right]\sin Z$$

and as this has only friction to oppose it, it may be effective in producing change of form in the waters of the lake. Assume that friction may be neglected. If the value of the horizontal component be computed for latitude 44°, which is about that of the middle of the lake, it is found, when the moon's declination is zero, to be 0.000 000 0568. As the surface of the lake is small in comparison with the surface of the earth, and as its curvature is also small, we may, as a tolerably close approximation, take it as plane, and assume the moon's relative force to be constant throughout its extent. The undisturbed surface of the lake is normal to the resultant of gravity and centrifugal force; when the surface is disturbed by the moon's action, the disturbed surface will be normal to the resultant of the above forces and the horizontal component of the relative force, and the value above given for the latter will express the inclination of the disturbed and undisturbed surfaces. The lake has approximately the form of a parallelopipedon, three hundred and twelve miles long from north to south, sixty miles wide, and 500 feet deep. Hence we shall obtain a maximum separation of the disturbed and undisturbed surfaces at the south end of the lake with the moon in the meridian. As the volume of the water of the lake is unchanged, at the middle of the lake the two surfaces will intersect, and, taking Milwaukee as fifty-five miles and Chicago one hundred and thirty-five miles south of the middle of the lake, and using the value above for the inclination of the two surfaces, we have their separation at Milwaukee as sixteen-thousandths (0.016) of a foot, and at Chicago forty-thousandths (0.040) of a foot. But these values of the rise of the tide have been deduced on the supposition of the equilibrium theory, that at every instant the surface of the lake has the precise form due to the disturbing forces at that instant. Now, with a constant force (such as the horizontal component of the relative force for an hour about the moon's transit in this case) acting against a resistance which increases from zero uniformly with the distance, (such a resistance as the water of the lake offers to being raised above the mean level of the lake,) the work of the constant force up to the moment the resistance becomes equal to it is double the work of the resistance, so that half the work of the constant force has been stored in the moving part, and will be given out before the motion ceases, giving thus a final displacement double that of equilibrium.

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Doubling, then, the values for the rise at Milwaukee and Chicago, obtained on the equilibrium theory, we have 0.032 foot and 0.08 foot respectively, or, taking the same value for the fall, we have a lunar tide of 0.064 foot at Milwaukee and of 0.16 foot at Chicago. The values found by observation are for Milwaukee 0.08 foot, and for Chicago (Colonel Graham's Lake Survey Report for 1863) 0.14 foot. It will be noticed that, in the theoretical computation, the moon's declination has been taken as zero. The lunar tide resulting from that declination is somewhat larger than the mean lunar tide; and it is the latter which is given by observation.

The agreement between theory and observation is quite close, and would be but slightly changed if in the theoretical computation that value of the moon's declination had been used which corresponds to the mean lunar tide.

Thus far only the lunar tide of upper culmination has been considered. The moon's mean declination is zero, and, for latitude 44°, this gives her zenith distance = 44° at upper culmination. At lower culmination her zenith distance will be 180°—44°; the horizontal component of the relative force will still be directed toward the south end of the lake, and its value will be diminished by $\frac{1}{17}$. That is, the lunar tide for lower culmination will be about $\frac{1}{17}$ less than for upper culmination. Plate II shows that the tides are nearly equal, and indicates that the lower culmination tide is the smallest, but this agreement, when the difference is so small, may be due to errors of observation.

The observations from which the solar diurnal curves given in Plate I are plotted are mostly contained between April 15 and November 15. Assuming, then, the sun's mean declination during this period as 11° north, his mean zenith distance for upper culmination at the middle of the lake will be 33° = Z. Taking his mass as 354936, his distance as 24065, we have for the horizontal component of his relative force when in the upper meridian of the middle of the lake—

$$354936\left[\frac{1}{(24065-\cos Z)^2}-\frac{1}{(24065^2)}\right]\sin Z$$

The value of this component differs but slightly for upper and lower culmination. It has its maximum value where Z = 45°. Computing its value for zero declination of the sun, it is found to be 0.000 000 0255, giving a solar semi-diurnal tide about half the lunar semi-diurnal tide. This result agrees with the ratio of the observed tides. For strict comparisons of curves, the declinations should be the same. Both solar and lunar semi-diurnal tides should vary, as will be found by examining the expressions for horizontal component for relative force, from a minimum value, when declination is greatest, to a maximum, (about $\frac{1}{2}$ and $\frac{1}{3}$ respectively larger than the minimum,) when the zenith distance is 45°. This would give the maximum luni-solar tide at syzygies, when both sun and moon were in or near the equator, and as the maximum solar semi-diurnal tide is nearly equal to the minimum lunar semi-diurnal tide, a minimum luni-solar tide should occur at quadratures, with the sun in the equator and the moon at her greatest declination.

Plate V, Fig. 1, shows the maximum luni-solar tide for several syzygies when both sun and moon are in or near the equator. Its amount is twelve-hundredths (0.12) of a foot. Fig. 2 gives the minimum tide for syzygies, both sun and moon having large declinations. Its amount is eight-hundredths (0.08) of a foot. It will be observed that the mean luni-solar tide at syzygies, Plate III, is intermediate between the two, as it should be.

It will be noticed on Plate I that the two solar semi-diurnal tides, instead of being equal, as they should be from theory, have a considerable inequality, the p. m. tide being the largest. The same inequality is carried with the solar tide into the syzygies and quadratures' tides, showing itself (Plates III and IV) both in the computed and observed curves. I attribute this inequality in height to the combination of the true tide with a small elevation of the water-surface occurring at about a constant hour in the afternoon of the solar day, and arising from the lake-breeze known to prevail at Milwaukee during the summer months, this period being included in the observations. For the existence of this lake-breeze, see the Lake-Survey Report for 1867. The effect of the lake-breeze would be to increase the apparent tide following the sun's upper transit, while, if there were a corresponding land-breeze, the tide following the sun's lower transit would be diminished.

To test the above explanation of the inequality of the solar semi-diurnal tides shown in Plate I, the solar curves were obtained from the record for July and August for two years, when from the stronger lake-breeze the inequality should be greatest, and the curves showed that this was the case. The same was done for April and November, when there is probably no lake-breeze, or a slight one, and in these the inequality in the two tides was reduced to a small amount, which may be attributed to errors of observation. The results are given in the tables of co-ordinates, Plate V. Figs. 3 and 4, Plate V, show the solar diurnal curves for April and November, and for July and August, for the years from 1868 to 1871, inclusive. The inequality during the summer months is thirty-three-thousandths (0.033) of a foot, while in the other months it is only ten-thousandths (0.010) of a foot.

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Co-ordinates, in hours and in decimals of a foot, for the mean solar diurnal water-level curve at Milwaukee, Wisconsin. (Plate I.)

Date.	A. M.											Noon.
	1	2	3	4	5	6	7	8	9	10	11	
1867	2.109	.107	.096	.090	.083	.070	.063	.075	.097	.095	.113	[illegible]
1868	.417	.416	.406	.404	.388	.387	.385	.399	.393	.409	.410	[illegible]
1869	.699	.679	.678	.673	.657	.669	.651	.689	.666	.684	.667	[illegible]
1870	.607	.600	.604	.590	.583	.566	.574	.569	.583	.575	.592	[illegible]
1871	.464	.459	.450	.456	.432	.440	.426	.441	.441	.463	.467	[illegible]
Mean	.459	.452	.447	.443	.429	.426	.424	.435	.436	.445	.454	[illegible]

Date.	P. M.											Mid-night.	Mean.
	1	2	3	4	5	6	7	8	9	10	11		
1867	.120	.118	.108	.100	.087	.088	.080	.096	.092	.103	.100	.109	[illegible]
1868	.435	.425	.420	.420	.405	.392	.411	.394	.411	.407	.420	.416	[illegible]
1869	.706	.710	.693	.694	.685	.675	.690	.669	.695	.677	.702	.672	[illegible]
1870	.612	.608	.601	.596	.576	.571	.577	.572	.581	.589	.588	.604	[illegible]
1871	.477	.468	.469	.457	.462	.439	.457	.438	.458	.449	.460	.457	[illegible]
Mean	.470	.466	.458	.453	.443	.433	.443	.434	.447	.445	.454	.452	[illegible]

Co-ordinates, in hours and feet, of the mean lunar diurnal water-level curves at Milwaukee, Wisconsin. (Plate II.)

Date.	LUNAR HOURS.											Upper transit.
	1	2	3	4	5	6	7	8	9	10	11	
1. Lunation from and including July 1 to July 29	2.518	2.485	2.501	2.464	2.470	2.439	2.435	2.456	2.465	2.499	2.491	[illegible]
2. Lunation from and including July 30 to August 28	2.443	2.454	2.427	2.420	2.386	2.383	2.396	2.379	2.400	2.407	2.442	[illegible]
3. Lunation from and including August 29 to September 26	2.223	2.240	2.188	2.184	2.145	2.161	2.173	2.185	2.200	2.198	2.205	[illegible]
4. Lunation from and including September 27 to October 26	1.971	1.979	1.924	1.922	1.899	1.917	1.901	1.896	1.922	1.911	1.972	[illegible]
5. Lunation from and including October 27 to November 24	1.510	1.478	1.461	1.457	1.447	1.416	1.462	1.454	1.452	1.488	1.505	[illegible]
Weighted mean of five lunations	2.130	2.124	2.097	2.086	2.066	2.060	2.070	2.070	2.084	2.097	2.121	[illegible]

Date	LUNAR HOURS.											Lower transit.	Mean.
	1	2	3	4	5	6	7	8	9	10	11		
1. Lunation from and including July 1 to July 29	2.509	2.505	2.488	2.480	2.452	2.440	2.441	2.488	2.488	2.509	2.507	2.534	[illegible]
2. Lunation from and including July 30 to August 28	2.456	2.448	2.419	2.416	2.401	2.386	2.373	2.370	2.405	2.416	2.415	2.456	[illegible]
3. Lunation from and including Aug. 29 to Sept. 26	2.233	2.234	2.231	2.213	2.194	2.173	2.156	2.202	2.188	2.204	2.207	2.229	[illegible]
4. Lunation from and including Sept. 27 to Oct. 26	1.986	1.957	1.922	1.909	1.904	1.893	1.897	1.903	1.918	1.943	1.957	1.963	[illegible]
5. Lunation from and including Oct. 27 to Nov. 24	1.510	1.501	1.489	1.461	1.465	1.450	1.415	1.439	1.420	1.453	1.479	1.505	[illegible]
Weighted mean of five lunations	2.140	2.130	2.111	2.097	2.084	2.069	2.057	2.081	2.085	2.106	2.114	2.146	[illegible]

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Mean Solar Diurnal Waterlevel-curve at Milwaukee, Wis.

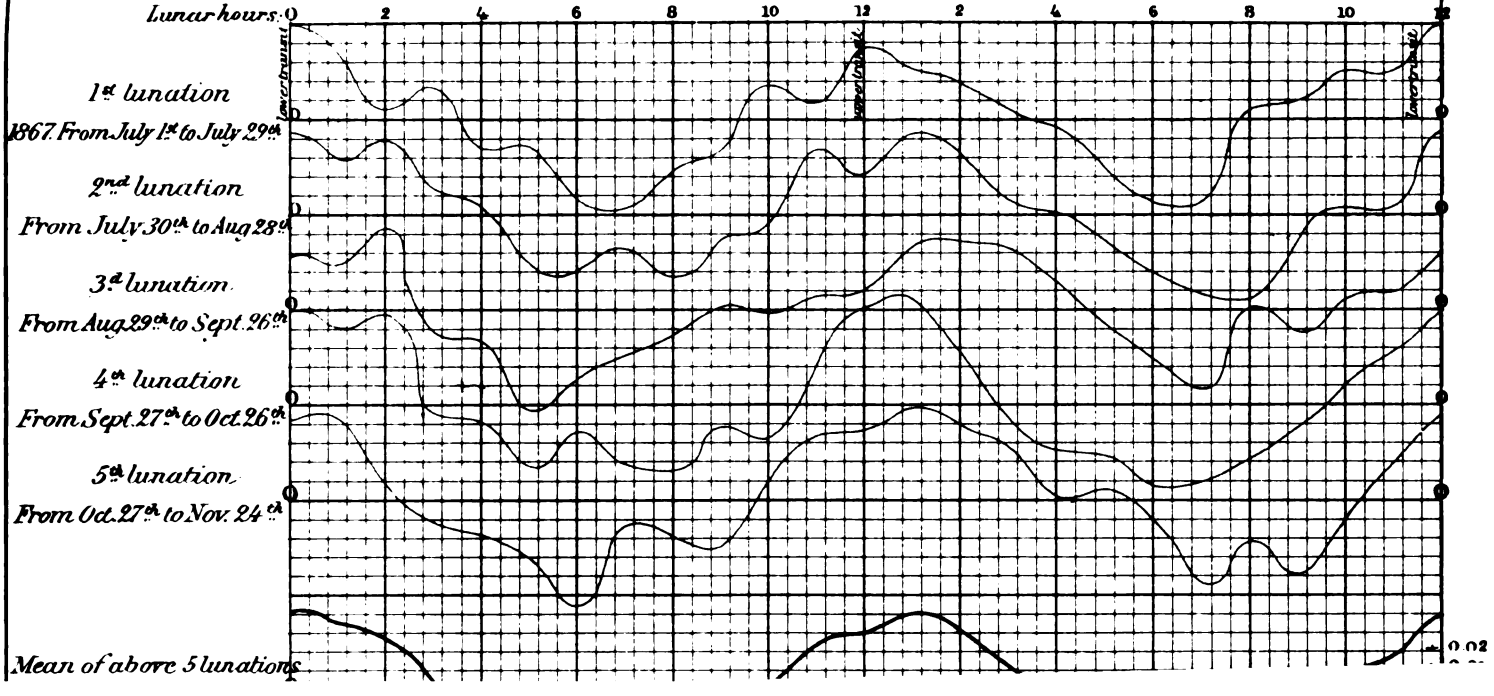


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Plate II.

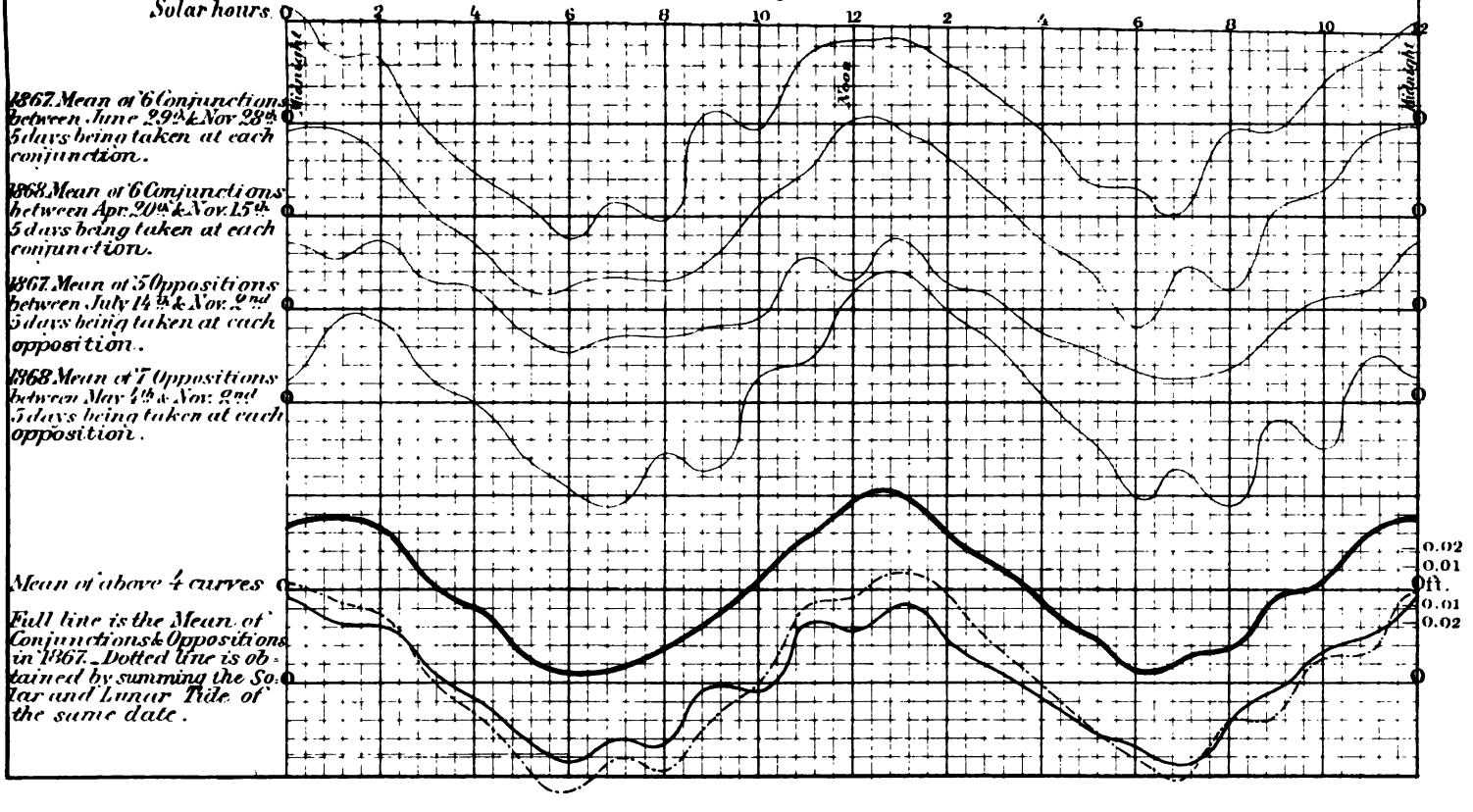
Mean Lunar Diurnal Waterlevel-curve at Milwaukee, Wis.



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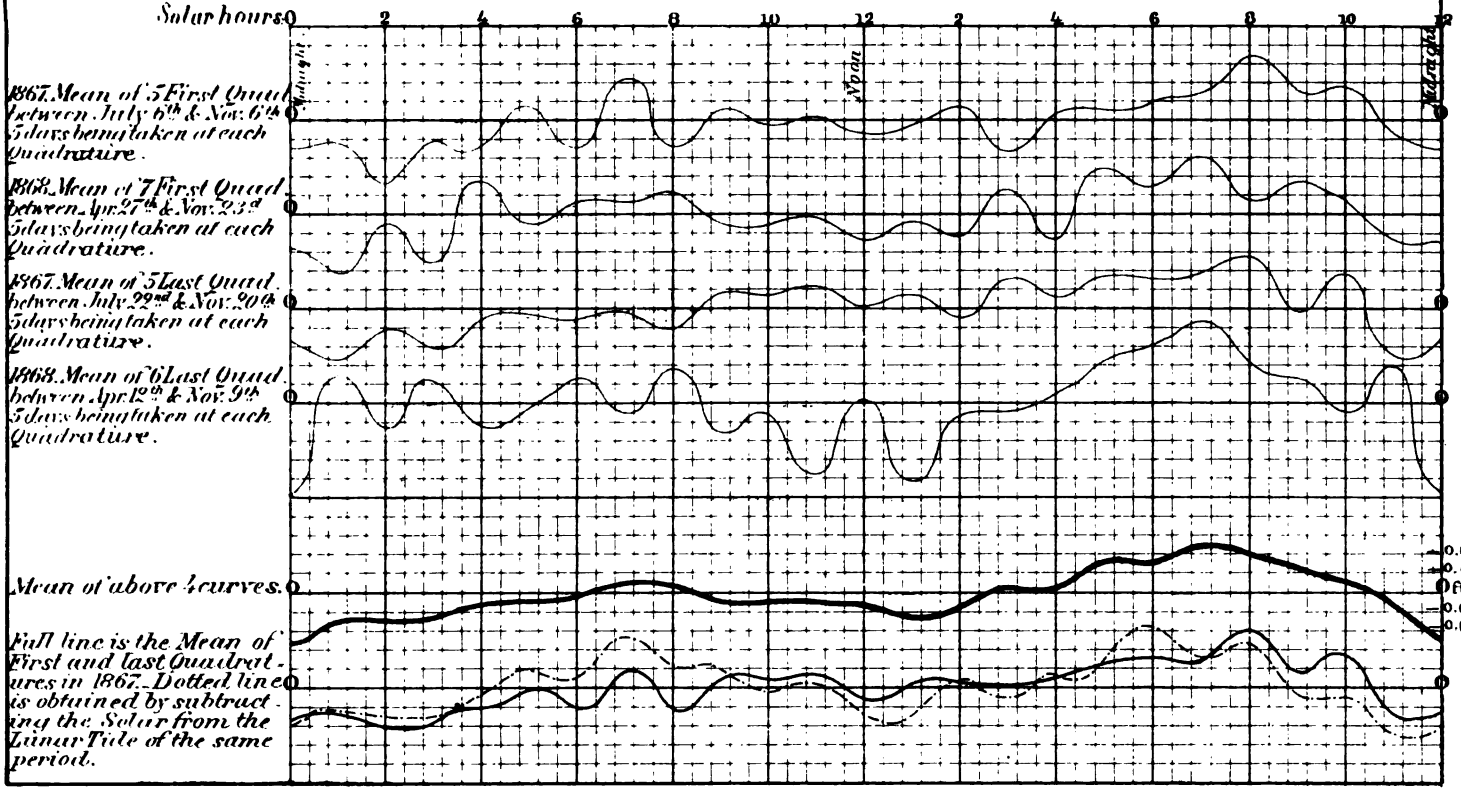
Mean Solar Diurnal Waterlevel-curve at Conjunctions & Oppositions at Milwaukee.



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Mean Solar Diurnal Water-level-curves at Quadratures at Milwaukee, Wis.

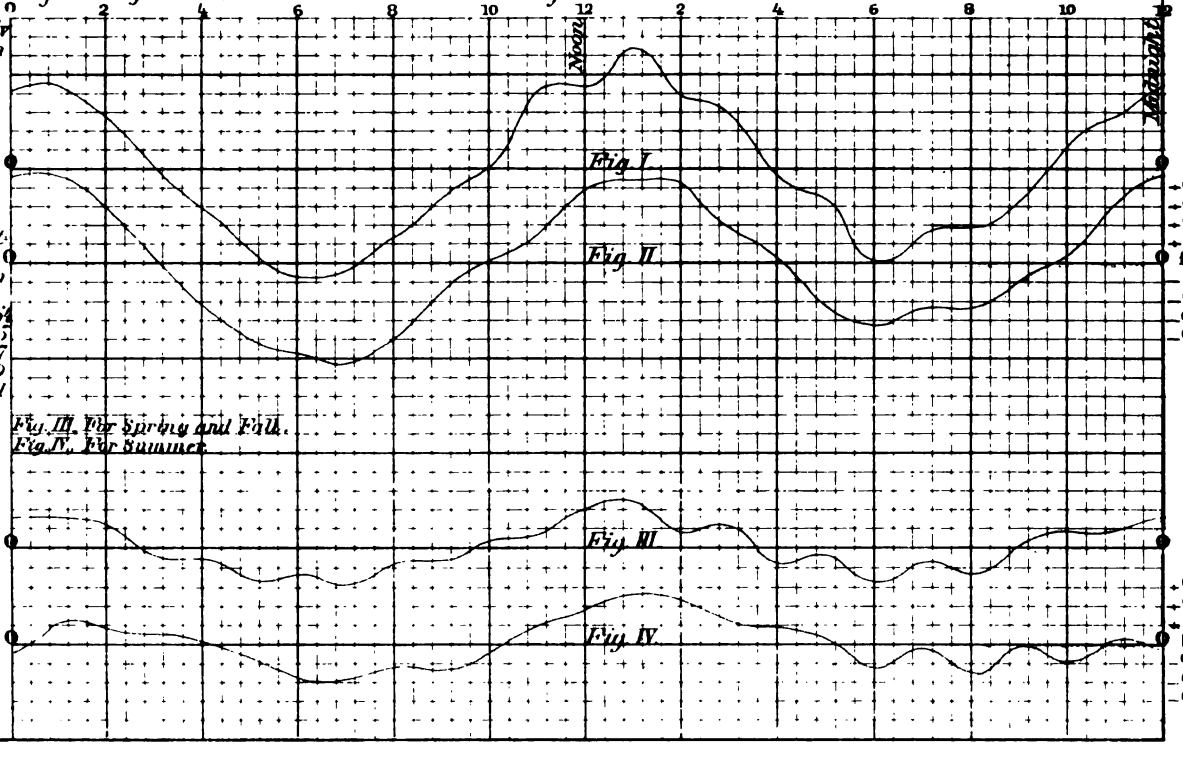


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Mean Diurnal Waterlevel-curves at Milwaukee, Wis.

Fig. I., For least declination of Sun and Moon at syzygies.
Fig. II., For greatest northern declination at conjunctions.



Mean curve from tridaily means for syzygies when Sun and Moon have the least declination.
at Sept. 13th 1867, Sept. 24th 1866.
" " 18 1867, " 27th 1867.
" " 16 1868, Oct. 1st 1868.
" " 20 1869, Sept. 24th 1870.
" Apr. 5th 1871, " 28th 1871.

Mean curve from tridaily means for conjunctions when Sun and Moon have the greatest northern declination:
at June 16th 1863, June 4th 1864
" July 3d 1864 " 23d 1865
" June 12th 1866, July 1st 1867
" " 20th 1868, " 8th 1869
" " 28th 1870, June 17th 1871
" July 17th 1871.

Fig. III., For Spring and Fall.
Fig. IV., For Summer.

Mean curve for:
Nov. 1867
Apr. and Nov. 1868.
May " Oct. 1869.
" " Nov. 1870.
Apr. " Oct. 1871.

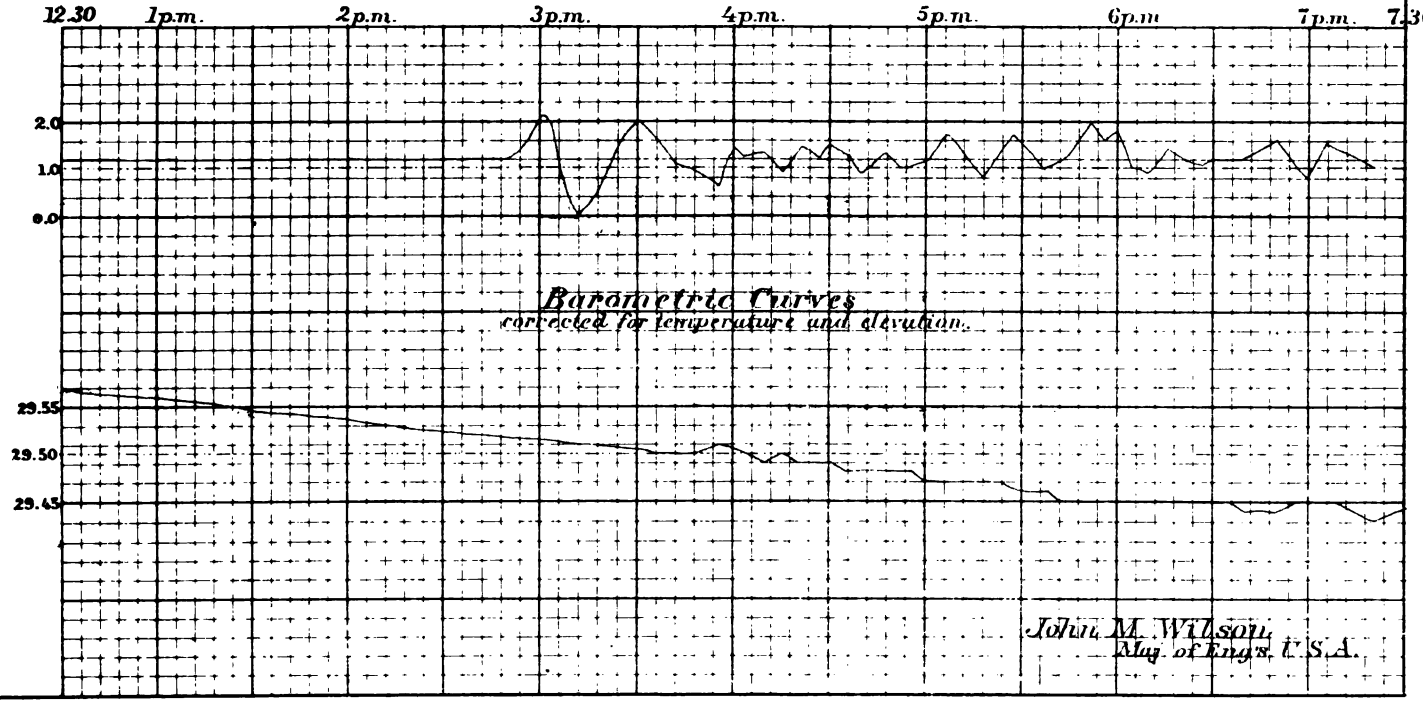
Mean curve for July & Aug. from 1867 to 1871.

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Curves showing level of Lake
as indicated by Water gauge at Oswego. June 13th 1872.



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Co ordinates in hours and feet for the mean, solar, diurnal, water-level curves at conjunctions, oppositions, and first and last quadratures, at Milwaukee, Wisconsin, 1867–'68.

CONJUNCTIONS AND OPPOSITIONS. (PLATE III.)

Date.	A. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon.
Mean of six conjunctions, 1867	2.124	2.123	2.084	2.063	2.045	2.027	2.046	2.038	2.097	2.088	2.128	2.131
Mean of six conjunctions, 1868	2.147	2.131	2.100	2.085	2.058	2.060	2.062	2.061	2.075	2.108	2.120	2.152
Mean of five oppositions, 1867	2.098	2.106	2.084	2.084	2.056	2.048	2.052	2.055	2.062	2.064	2.105	2.083
Mean of seven oppositions, 1868	2.206	2.203	2.173	2.161	2.129	2.114	2.102	2.131	2.122	2.179	2.182	2.221
Weighted mean of conjunctions and oppositions, 1867 and 1868	2.148	2.145	2.114	2.101	2.075	2.065	2.068	2.074	2.092	2.114	2.137	2.153
Mean of conjunctions and oppositions, 1867	2.111	2.114	2.084	2.074	2.050	2.038	2.049	2.046	2.080	2.076	2.116	2.107

Date.	P. M.												Means.
	1	2	3	4	5	6	7	8	9	10	11	Mid-night.	
Mean of six conjunctions, 1867	2.134	2.122	2.104	2.085	2.057	2.058	2.040	2.088	2.086	2.113	2.126	2.145	2.090
Mean of six conjunctions, 1868	2.147	2.131	2.110	2.085	2.071	2.037	2.070	2.058	2.103	2.112	2.142	2.147	2.099
Mean of five oppositions, 1867	2.118	2.082	2.079	2.057	2.048	2.037	2.034	2.038	2.062	2.075	2.082	2.108	2.071
Mean of seven oppositions, 1868	2.231	2.210	2.193	2.167	2.150	2.108	2.123	2.102	2.152	2.135	2.185	2.174	2.160
Weighted mean of conjunctions and oppositions, 1867 and 1868	2.161	2.141	2.126	2.193	2.086	2.063	2.071	2.074	2.104	2.111	2.138	2.146	2.109
Mean of conjunctions and oppositions, 1867	2.123	2.102	2.091	2.071	2.053	2.047	2.037	2.063	2.074	2.094	2.104	2.126	2.081

QUADRATURES. (PLATE IV.)

Date.	A. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon.
Mean of five first quadratures, 1867	2.122	2.102	2.124	2.120	2.140	2.119	2.156	2.119	2.138	2.132	2.135	2.126
Mean of seven first quadratures, 1868	2.281	2.305	2.286	2.327	2.306	2.320	2.320	2.323	2.306	2.305	2.310	2.297
Mean of five last quadratures, 1867	2.010	2.027	2.016	2.028	2.030	2.032	2.037	2.026	2.046	2.044	2.050	2.036
Mean of six last quadratures, 1868	2.235	2.207	2.231	2.204	2.214	2.231	2.213	2.240	2.199	2.213	2.178	2.220
Weighted mean of quadratures, 1867 and 1868	2.175	2.175	2.178	2.185	2.186	2.191	2.195	2.192	2.165	2.187	2.183	2.183
Mean of first and last quadratures, 1867	2.066	2.064	2.070	2.074	2.085	2.076	2.096	2.073	2.092	2.088	2.093	2.081

Date.	P. M.												Means.
	1	2	3	4	5	6	7	8	9	10	11	Mid-night.	
Mean of five first quadratures, 1867	2.130	2.142	2.118	2.140	2.137	2.145	2.146	2.169	2.150	2.153	2.127	2.120	2.134
Mean of seven first quadratures, 1868	2.307	2.299	2.325	2.300	2.339	2.323	2.343	2.319	2.328	2.318	2.295	2.295	2.311
Mean of five last quadratures, 1867	2.044	2.032	2.054	2.042	2.053	2.054	2.054	2.066	2.036	2.044	2.011	2.018	2.037
Mean of six last quadratures, 1868	2.178	2.213	2.213	2.223	2.243	2.250	2.261	2.239	2.235	2.211	2.240	2.172	2.219
Weighted mean of quadratures, 1867 and 1868	2.178	2.184	2.192	2.189	2.208	2.207	2.216	2.211	2.201	2.195	2.183	2.165	2.189
Mean of first and last quadratures, 1867	2.087	2.087	2.086	2.091	2.095	2.099	2.100	2.118	2.093	2.098	2.069	2.069	2.086

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Co-ordinates in hours and feet for the mean diurnal water-level curves at Milwaukee, Wis., for least declination of sun and moon at syzygies, and for greatest northern declination at conjunctions; also for spring and fall, and for summer.

(PLATE V.

	A. M.										
	1	2	3	4	5	6	7	8	9	10	11
Least declination of sun and moon at syzygies	2.281	2.268	2.236	2.218	2.192	2.187	2.186	2.203	2.222	2.252	[illegible]
Greatest northern declination at conjunctions	2.732	2.719	2.692	2.667	2.648	2.641	2.639	2.650	2.676	2.691	[illegible]
Spring and fall	2.055	2.051	2.036	2.035	2.021	2.024	2.030	2.032	2.031	2.045	[illegible]
Summer	2.215	2.212	2.208	2.204	2.193	2.185	2.184	2.192	2.191	2.195	[illegible]

	P. M.										
	1	2	3	4	5	6	7	8	9	10	11
Least declination of sun and moon at syzygies	2.302	2.277	2.272	2.235	2.223	2.189	2.203	2.206	2.219	2.251	2.284
Greatest northern declination at conjunctions	2.732	2.732	2.708	2.692	2.666	2.657	2.668	2.665	2.681	2.694	2.723
Spring and fall	2.062	2.048	2.053	2.030	2.035	2.023	2.034	2.028	2.041	2.049	2.067
Summer	2.230	2.227	2.215	2.212	2.208	2.190	2.202	2.188	2.203	2.192	2.206

APPENDIX B.

IRREGULAR OSCILLATIONS IN SURFACE OF LAKE MICHIGAN, AT MILWAUKEE.

On examining the sheets of the self-registering tide-gauge at Milwaukee for 18[illegible] and the following years, it is found that aside from the gradual rise and fall of the water of the lake, there is more than half of the time a series of waves whose lengths vary in time from one to three hours, and whose heights are from three-tenths of a foot up to one and five-tenths feet in extreme cases. On an average there are about six or eight times in a year when these waves exceed eight-tenths of a foot in height. Sometimes for several days they almost or quite disappear, leaving no oscillations of more than one or two-tenths of a foot. Counting these waves, it is found that when they are of regular form, their number is in most cases eleven in each day, sometimes reaching twelve, and sometimes apparently splitting up into twenty-two.

In examining these oscillations, the average value of the oscillations for each two hours was read off from the tide-gauge record for 1867 and 1868, and plotted, days being taken as abscissas, and these heights as ordinates. Immediately below with the same abscissas the heights of the barometer were plotted as ordinates. An inspection of the curves shows that, as a rule, a rising barometer is soon followed by diminished heights of oscillations, and a falling barometer by increased heights, a steady high barometer always giving small oscillations, while large oscillations are usually accompanied by a low barometer. The oscillation of the barometer affects the lake in two ways. First, if the change is not at any instant the same for the whole lake, the difference will produce a relative change of level at the two places of about thirteen times its amount. Thus, if the barometer at Mackinac were to fall one inch and then rise again while the barometer at Milwaukee was stationary, a wave 26 inches in height would start from Mackinac for Milwaukee, its diminution in size as it moved on depending on the area of depressed barometer. If that area included the whole north end of the lake, the waves would still be large when they reached Milwaukee. The second way in which a change of the barometer affects the surface of the lake is through the winds which result from it. These winds heap up the water on the shore to which they blow, and when they cease a reflux wave moves from that shore. Among these winds must be included the lake-breeze which exists at Milwaukee during the warm months. These irregular oscillations are sometimes known as seiches, though that term appears to be confined usually to rapid and extreme oscillations.

By referring to the Lake Survey Report for 1861, an examination of these oscillations at Marquette will be found. The conclusions drawn then are that in all cases of the fluctuations "there was a considerable depression of the barometer, that the sky, with a single exception was covered with clouds, and that in two cases there was rain either during their continuance or for several days subsequent."

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An examination of nineteen cases in which the oscillations at Milwaukee between May 22, 1870, and June 12, 1872, had reached or exceeded eight-tenths of a foot in height, showed that within twenty-four hours of the oscillations, the barometer had in eight cases varied in height by more than three-tenths of an inch; that in eighteen cases the barometer had been from six to forty-five hundredths of an inch below its mean monthly height; that in nine cases there was rain; and in eleven, a large amount of cloudiness.

In nearly all cases there is then a greater or lesser barometric depression, and in many an unstable state of the atmosphere at the point of observation.

It must be remembered that these data as to weather apply only to the stations of observations, and that if an oscillation of the surface of the lake was produced by a local atmospheric disturbance, such as often occurs during the summer months, the disturbance of the lake might be transmitted to the recording tide-gauge without there being any indication of atmospheric disturbance at that point.

Atmospheric disturbance, or more definitely barometric oscillations and their accompanying winds, appear then to be the probable cause of these oscillations of the surface of the lake. To prove that they are the cause in all cases would require a set of meteorological observers so distributed over the lake that no local atmospheric disturbance could escape record.

The question now occurs, Why should there be at Milwaukee in a large majority of cases about eleven of these oscillations in a day? Taking the mean depth of the lake from Milwaukee to Grand Haven as 400 feet, the corresponding velocity of a free wave between those points would be seventy-seven miles an hour; or such a wave could make the round trip in a little more than two hours, or, continuing, could cross and recross the lake eleven times in a day.

The coincidence of this number with that of oscillations in a day, suggests the idea that, after a wave has once occurred at Milwaukee, its crest being nearly parallel with the shore there, it may be repeated by reflection from the opposite shore. As a rule, barometric disturbances cross the lake from west to east, thus giving a wave parallel to the shore; and if a wave were to move from the north end of the lake, the smaller velocity of transmission near the shores would continually bring that part of the wave more and more nearly parallel to the shores.

The oscillations considered thus far have had a period of about two hours. Those referred to at Marquette, in the Lake Survey Report for 1861, had an average period of about thirty minutes. Those at Eagle River, described by Whittlesey in his article on North American lakes in the Smithsonian Contributions for 1859, vary in period from two to thirteen minutes.

In the annual report for the Lake Survey for 1871, I suggested as one of the causes for sudden and extreme oscillations of the surface of a lake, the passage of a tornado, perhaps at a considerable distance from the point at which the oscillations were observed. No such event so far as is known has been registered upon any of the Lake Survey tide-gauges, but through the kindness of Major J. M. Wilson, Corps of Engineers, for which I am much indebted, I have been furnished with the following information, which appears to establish the generation of oscillations, which may extend to a considerable distance, by the passage over the lake of a local storm:

"UNITED STATES ENGINEER OFFICE,
"*Oswego, New York, June* 24, 1872.

"MY DEAR GENERAL: Knowing the interest you have taken in the subject of tides on the lakes, I transmit herewith a drawing showing the observations made under my direction during the rise and fall of the water here on the 13th instant; I have been so busy that I could not send it before; as you will perceive, between 2 and 3 p. m. the water suddenly rose one foot in ten minutes, and then fell two feet in twenty minutes, and afterward continued to rise and fall until 7 o'clock, the barometer falling nearly all the time.

"At ten minutes past 3 I am informed a white squall and water-spout passed about one and a half miles to the northwest, moving west. At half past 3 my overseer of harbor work tells me that the water around his boat was suddenly covered with bubbles; the fish came to the surface apparently paralyzed for an instant and then disappeared; the bubbles were accompanied by a slight rumbling sound. As far as I can learn this wave was noticed all along the lake on this side.

"Yours, very truly,

"JOHN M. WILSON,
"*Major of Engineers, U. S. A.*

"General C. B. COMSTOCK, *Detroit, Michigan.*"

"OSWEGO, NEW YORK, *June* 28, 1872.

"DEAR GENERAL: I am informed that the wave of the 13th instant was noticed at Charlotte, eighty miles west of this place; at Oak Orchard, one hundred miles from here; although I am dredging there, the dredge people did not notice it; but at Olcott,

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one hundred and twelve miles west of us, the people report having seen an "immense sea-serpent" lashing the waves, which I presume was the water-spout. I have heard nothing from the east of us in reference to it.

"You can make whatever use you may think proper of the diagram.

"Yours, very truly,

"JOHN M. WILSON.

"General COMSTOCK, *Detroit.*"

The diagram sent by Major Wilson is given in Plate VI. It will be noticed that the period of oscillations is from twenty to thirty minutes. From his information it would seem that the oscillation extended to one hundred and twelve miles west of Oswego: but as the local storm moved toward the west, the oscillation there may not have been derived from Oswego, but from some point to the west of it.

It would seem, then, from the consideration of the irregular fluctuations at Milwaukee, Marquette, and Oswego, that a probable cause is to be found in oscillations of the barometer, either local or general, and in the accompanying winds, periodicity arising in some cases by reflection from an opposite shore.

C. B. C.

APPENDIX C.

ADJUSTMENT OF A TRIANGULATION WHERE ANGLES, NOT DIRECTIONS, ARE THE DATA, AND WHERE THERE IS A SINGLE MEASURED BASE.

Chauvenet gives (Astronomy, Vol. II, 554) one form of the application of the method of least squares to conditional observations. Using his notation, we are to make the expression—

$$p' v'^2 + p'' v''^2 + p''' v'''^2 + \ldots \qquad (90)$$

a minimum subject to the conditions—

$$\left\{\begin{aligned} &n' + a' v' + a'' v'' + a''' v''' + \ldots = 0 \\ &n'' + b' v' + b'' v'' + b''' v''' + \ldots = 0 \\ &n''' + c' v' + c'' v'' + c''' v''' + \ldots = 0 \\ &\ldots\ldots\ldots\ldots\ldots\ldots \end{aligned}\right. \qquad (89)$$

In these expressions, p', p'', p''', &c., are the weights of the observed angles, and v', v'', v''', &c., the most probable corrections, which, applied to the observed values m', m'', m''', &c., give the most probable values of the observed quantities V', V'', V''', &c.

2. The general solution of the problem of finding the values of v', v'', v''', &c., consists in substituting in (90) the values of n of the v's derived from the n equations of condition (89), and afterward making (90) an absolute minimum. Another form of the solution is that in which correlates are used, and is that given by Chauvenet, all the equations of condition being treated alike. This requires as many correlates and as many final equations for their determination as there are equations of condition.

Where in addition to the side and angle equations there are also many equations of condition arising from the measurement of the sum-angles, this process gives a great number of correlates and excessive labor in solving their final equations.

3. The number of correlates can be reduced, by combining the direct and indirect solutions, eliminate from the differential equation for the minimum—

$$p' v' dv' + p'' v'' dv'' + \ldots + p^{(m)} v^{(m)} dv^{(m)} + \ldots + p^{(n)} v^{(n)} dv^{(n)} \ldots = 0 \qquad (91)$$

as many of the corrections v as there are equations of condition arising from the sum-angles; the resulting minimum equation, if there were no other equations of condition, (side or angle,) would, by placing the co-efficients of dv', dv'', &c., separately equal to zero, give the most probable values of v', v'', v''', &c. As others do exist, the resulting minimum equation is conditioned by them, and v', v'' . . . , are to be found by combining it with them. If the elimination is done by the aid of correlates, the number of them, and of their final equations, will be less than before by the number of equations of condition arising from sum-angles.

4. The solution sketched in § 3 is as follows:

If the mth term in (91) involves sum-angles, so that in—

$$v^{(m)} = V^{(m)} - M^{(m)}$$

we have—

$$V^{(m)} = V' + V'' + \ldots$$

then we shall have—

$$p^{(m)} v^{(m)} dv^{(m)} = p^{(m)} (v' + M' + v'' + M'' + \ldots - M^{(m)})(dv' + dv'' \ldots)$$

and substituting in (91) it becomes—

$$\begin{aligned} &p' v' dv' + p'' v'' dv'' + \ldots \\ &+ p^{(m)} (v' + M' + v'' + M'' \ldots - M^{(m)}) (dv' + dv'' + \ldots) \\ &+ \ldots + p^{(n)} v^{(n)} dv^{(n)} + \ldots = 0 \end{aligned} \qquad (91)'$$

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If the nth angle were also a sum-angle, a similar substitution would be made.

Arranging (91)′ with reference to dv', dv'', ... , and supposing the nth, also, to be a sum-angle, we have—

$$(91)''\quad \left.\begin{array}{l} p' v' + \ldots \\ + p^{(m)}[v' + v'' \ldots + (M' + M'' + \ldots - M^{(m)})] \\ + \ldots \\ + p^{(n)}[v' + v'' \ldots + (M' + M'' + \ldots - M^{(n)})] \end{array}\right\} dv'$$

$$\left.\begin{array}{l} + p'' v'' + \ldots \\ + p^{(m)}[v' + v'' + \ldots + (M' + M'' + \ldots - M^{(m)})] \\ + \ldots \\ + p^{(n)}[v' + v'' + \ldots + (M' + M'' + \ldots - M^{(n)})] \end{array}\right\} dv'' + \ldots = 0$$

which may be written—

$$(91)'''\quad \begin{array}{l} (a' v' + a'' v'' + \ldots + \lambda')\, dv' \\ + (\beta' v' + \beta'' v'' + \ldots + \lambda'')\, dv'' \\ + \ldots = 0 \end{array}$$

This is the resulting minimum equation, and placing the co-efficients of dv', dv'', . . , each equal to zero, we shall have the most probable values of v', v'', . . , so far as they depend on the local conditions of each station (that is, on the sum-angles) alone.

Differentiating (89), which now contains only side and angle equations, we have the further conditions which (91)‴ must satisfy; they are—

$$(92)\quad \left\{\begin{array}{lll} a' dv' + a'' dv'' + a''' dv''' + \ldots = 0 & & \text{I} \\ b' dv' + b'' dv'' + b''' dv''' + \ldots = 0 & & \text{II} \\ c' dv' + c'' dv'' + c''' dv''' + \ldots = 0 & & \text{III} \\ \ldots\ldots\ldots\ldots\ldots\ldots & & \end{array}\right.$$

Multiplying these equations in order by the undetermined factors or correlates I, II, III, . . , adding the products to (91)‴ with its signs changed, and then placing the co-efficients of dv', dv'', . . . , separately equal to zero, we have—

$$(93)'\quad \left\{\begin{array}{lll} a' v' + a'' v'' + a''' v''' \ldots + \lambda' = a'\ \text{I} + b'\ \text{II} + c'\ \text{III} \ldots \\ \beta' v' + \beta'' v'' + \beta''' v''' \ldots + \lambda'' = a''\ \text{I} + b''\ \text{II} + c''\ \text{III} \ldots \\ \gamma' v' + \gamma'' v'' + \gamma''' v''' \ldots + \lambda''' = a'''\ \text{I} + b'''\ \text{II} + c'''\ \text{III} \ldots \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{array}\right.$$

In these equations everything is known but the corrections v', v'', . . , and the correlates I, II, III, . . If there are m independent angles, and n equations of conditions, there will be m equations in (93)′ from which the values of the m corrections can be found in terms of the n correlates. Substituting these values in (89) we shall have n equations containing the n correlates as unknowns, and hence their values can be found. Substituting these values back in the values found for the m corrections and we have the latter in terms of known quantities, and therefore the values of the angles which give the minimum sum of residual squares, all the rigid equations of condition being satisfied.

5. A modification of the solution just given will usually diminish the numerical work.

Write—

$$(94)\quad \left\{\begin{array}{l} v' = (v') + [v'] \\ v'' = (v'') + [v''] \\ \ldots\ldots \end{array}\right.$$

in which (v'), (v''), ..., are the corrections arising at the station from the local conditions, (sum-angles,) and are obtained by placing in (91)″ the co-efficients of dv', dv'', . . ., separately equal to zero, and finding from the resulting equations the local values of v', v'', . . ., and $[v']$, $[v'']$, ..., are corrections arising from the side and angle equations to be added to these local corrections to obtain the final or total corrections to observed angles. Substituting in (93)′ the values of v', v'', ..., in (94), and recollecting that—

$$\begin{array}{l} a' (v') + a'' (v'') + a''' (v''') \ldots + \lambda' = 0 \\ \beta' (v') + \beta'' (v'') + \beta''' (v''') \ldots + \lambda'' = 0 \\ \ldots\ldots\ldots\ldots\ldots\ldots \end{array}$$

we have—

$$(93)''\quad \left\{\begin{array}{lll} a' [v'] + a'' [v''] + a''' [v'''] + \ldots = a'\ \text{I} + b'\ \text{II} + c'\ \text{III} \ldots \\ \beta' [v'] + \beta'' [v''] + \beta''' [v'''] + \ldots = a''\ \text{I} + b''\ \text{II} + c''\ \text{III} \ldots \\ \gamma' [v'] + \gamma'' [v''] + \gamma''' [v'''] + \ldots = a'''\ \text{I} + b'''\ \text{II} + c'''\ \text{III} \ldots \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{array}\right.$$

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Making the same substitution in (89), we have—

$$(89)' \quad \begin{cases} n'_0 + a'[v'] + a''[v''] + a'''[v'''] \ . \ . \ . \ = 0 \\ n''_0 + b'[v'] + b''[v''] + b'''[v'''] \ . \ . \ . \ = 0 \\ n'''_0 + c'[v'] + c''[v''] + c'''[v'''] \ . \ . \ . \ = 0 \\ \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \end{cases}$$

in which—

$$(94) \quad \begin{cases} n'_0 = n' + a'(v') + a''(v'') + \ . \ . \ . \ = \text{a known quantity,} \\ n''_0 = n'' + b'(v') + b''(v'') + \ . \ . \ . \ = \text{a known quantity,} \\ n'''_0 = n''' + c'(v') + c''(v'') + \ . \ . \ . \ = \text{a known quantity,} \\ \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \end{cases}$$

(89)′ will result directly, if in forming numerical equations of condition (89), we use the locally-corrected values of the observed angles instead of the observed angles themselves.

The values of $[v']$, $[v'']$, ... , are to be found from (93)″ and (89)′, precisely as those of v', v'', ... , would be from (93)′ and (89). Having found these the final values of the angles which satisfy all the conditions and make the sum of the weighted residual squares a minimum result, on applying them to the locally-corrected values of the angles.

SUMMARY.

Number the stations from one end of the triangulation to be adjusted to the other. At each station select as fundamental angles those measured angles on which all measured angles can be made to depend.

Number these angles, starting from the south point and going round by the west.

Then any angle will be represented by a number with a subscript number. Thus 12_3 is the third angle at the twelfth station, $12_3'$ is the mean of the measurements of the angle; (12_3) is the local correction to be applied to $12_3'$ arising from observations at this station alone; and $[12_3]$ is the further correction arising from the side and angle equations which will give the final most probable value of 12_3.

Any sum-angle measured (including angles which close the horizon) will be expressed in terms of the fundamental angles which make it up.

1°. For any station write out so many terms of (91)″ as will include differentials of all fundamental angles measured at that station, sum-angles being expressed in terms of the fundamental angles. If there were l fundamental angles at 12, we should replace in (91)″, dv', dv'', dv''', ... , $dv^{(l)}$, by $d\,(12_1)$, $d\,(12_2)$, $d\,(12_3)$, ... $(d\,12_l)$.

Place the co-efficients of $d\,(12_1)$, ... , separately equal to zero, and we have equations which will give the local l corrections (12_1), (12_2), (12_3), ... at this station.

The values of a', a'', ... , β', β'', ... , in (91)‴, are now known.

Do the same for each station.

2°. Write out the angle and side equations in the form (89), and a', a'', ... b', b'', ... , are then known.

3°. Find from (94) the values of the known quantities n_0', n_0'', ... ; then write out equations (93)″ and (89)′, in which $[v']$, $[v'']$, ... , are replaced by $[1_1]$, ... , $[m_n]$, ... , which, with I, II, III, ... , are the only unknowns in them. Find from this form of (93)″ the values of $[1_1]$, ... $[m_n]$, in terms of I, II, III, ... , and substitute these values in the new form of (89). There will be n of these equations containing as unknowns only the quantities relates, whose values may now be found.

4°. Substitute the values of I, II, III, ... , in the values of $[1_1]$, ... $[m_n]$, just found, and the latter will be given in terms of known quantities.

5°. Apply these corrections $[1_1]$, . . . , $[m_n]$, to the local most probable values of the angles, and we have the final most probable values, satisfying all the conditions and making the sum of the weighted residual squares a minimum.

Note on formation of equations of condition in the adjustment of a triangulation with but one measured base.

1. In a triangulation which is a closed geometrical figure, there are certain mathematical conditions which must be rigidly fulfilled by the true values of the angles. We write in the form of an equation such a rigid condition, and then substitute for the true angles, their observed values plus their unknown most probable corrections; we shall have such a numerical equation of condition as we are to consider. In the present case those equations are of three kinds:

1°. Those local equations arising at any given station from the measurement of the angles, including under this head angles which at a station close the horizon.

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The rigid condition in this is of the form—

$$P = A \pm B \pm C \pm \ . \ . \ .$$

when P is the true sum-angle and A, B, C, the true partial angles. Denote the observed values of the angles by P', A', B', ... , and the most probable corrections to the latter by v', v'', v''', ... Substituting in the rigid equation of condition the observed values plus their corrections we have the numerical equation of condition—

$$P' + v^{(n)} = A' + v' + B' + v'' + C' + v''' \ . \ . \ .$$

which may be written in the form—

$$n' + a' v' + a'' v'' + a''' v''' \ . \ . \ . \ = 0$$

2°. Equations arising from the necessity that the sum of the angles of a spherical triangle shall equal $180° + \varepsilon$ when ε is the spherical excess.

The rigid equation is—

$$A + B + C = 180° + \varepsilon$$

and the numerical equation, derived as before, is—

$$A' + v' + B' + v'' + C' + v''' = 180° + \varepsilon$$

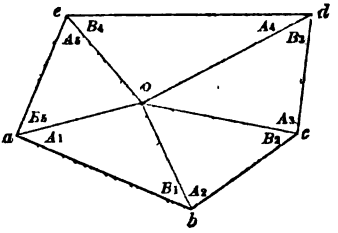
which may be written in the form—

$$n' + a' v' + a'' v'' + a''' v''' \ . \ . \ . \ = 0$$

These are called angle-equations.

3°. Equations arising from the necessity that in a geometrical figure any side computed from another side shall be the same by whatever route computed. These are called side-equations.

Thus, in the figure, cd must have the same value when computed by whatever route from ab.



We have—

$$ab \cdot \frac{bo}{ab} \cdot \frac{co}{bo} \cdot \frac{od}{co} = cd$$

and also—

$$ab \cdot \frac{ao}{ab} \cdot \frac{eo}{ao} \cdot \frac{do}{eo} \cdot \frac{cd}{do} = cd$$

or, dividing one equation by the other—

$$1 = \frac{bo}{ao} \cdot \frac{co}{bo} \cdot \frac{do}{co} \cdot \frac{eo}{do} \cdot \frac{ao}{eo}$$

From the proportionality of the sines of the angles to the opposite sides, this becomes—

$$1 = \frac{\sin A_1}{\sin B_1} \cdot \frac{\sin A_2}{\sin B_2} \cdot \frac{\sin A_3}{\sin B_3} \cdot \frac{\sin A_4}{\sin B_4} \cdot \frac{\sin A_5}{\sin B_5}$$

which is the rigid equation of condition.

Substituting, as before, for the true angles their observed values, A'_1, A'_2, ... , plus the most probable correction, v', v'', ... , we have the numerical equation condition—

$$(3)\quad 1 = \frac{\sin (A'_1 + v')}{\sin (B'_1 + v^{vi})} \cdot \frac{\sin (A'_2 + v'')}{\sin (B'_2 + v^{vii})} \cdot \frac{\sin (A'_3 + v''')}{\sin (B'_3 + v^{viii})} \cdot \frac{\sin (A'_4 + v^{iv})}{\sin (B'_4 + v^{ix})} \cdot \frac{\sin (A'_5 + v^{v})}{\sin (B'_5 + v^{x})}$$

To get this into a linear form, the simplest way is to take the logarithm of (3), giving—

$$(3)'\quad \log \sin (A'_1 + v') + \log \sin (A'_2 + v'') + \log \sin (A'_3 + v''') + \ . \ . \ .$$
$$= \log \sin (B'_1 + v^{vi}) + \log \sin (B'_2 + v^{vii}) + \ . \ . \ .$$

and to recollect that since v', v'', ... , are only one or two seconds, we may write—

$$\log \sin (A'_1 + v') = \log \sin A'_1 + \left(\frac{d}{dA'_1} \log \sin A'_1 \right) v'$$

$$\log \sin (A'_2 + v'') = \log \sin A'_2 + \left(\frac{d}{dA'_2} \log \sin A'_2 \right) v''$$

. . . . . .

in which, if the angles are in seconds, we may replace— .

$$\frac{d}{dA'_1} \log \sin A'_1, \text{ &c.,} \ . \ . \ .$$

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by the tabular difference corresponding to one second for the angle A'_1 in a table of logarithmic sines, calling the tabular differences—

$$\delta', \delta'', \delta''' \quad . \quad . \quad .$$

(3)′ becomes—

$$\log \sin A'_1 + \delta' v' + \log \sin A'_2 + \delta'' v'' \quad . \quad . \quad .$$
$$= \log \sin B_1' + \delta^{vi} v^{vi} + \log \sin B'_2 + \delta^{vii} v^{vii}$$

which may be written in the form—

$$n' + a' v' + a'' v'' + \quad . \quad . \quad . \quad = 0$$

2. We have now shown how to obtain the numercial equations of condition from rigid geometrical ones. As there is sometimes difficulty in selecting the latter, these remarks may be useful, as, if too few are selected, the adjustment will be incomplete and if too many, (some not being independent,) the labor will be unnecessarily increased.

In a continuous triangulation, one measured base and two measured angles in each triangle will absolutely fix all other parts of the triangulation by computation. If any of those other parts are also measured, each such part will give an equation of condition.

Side-equations.—From a known side two directions fix a third point. From any two these three points two directions fix a fourth point, and so on. In a net of p points of which two are known, being the ends of the base, $p-2$ will have to be fixed and will require $2(p-2)$ directions from known points. Any additional direction observed from a known point will be superfluous and will give a side-equation. If the p points be connected by l lines observed over from a known toward the unknown, we shall have, excluding the base, $l-1$ directions, of which $l-1-2(p-2)$ are superfluous, giving $l-2p+3$ side-equations.

Angle-equations.—In a polygon of p sides, the sum of the angles is known, and hence gives an equation of condition. If two of its vertices be connected by a new line two new polygons will be formed, giving two new known sums, but only one independent equation of condition, since one of the sums depends on the other and the original one.

Hence each new line which must be observed over from both ends gives an angle-equation. When there are l lines there will be $l-p+1$ angle-equations.

The number of side and angle equations now being known, to find them proceed as follows:

Starting from known points, two directions toward a new point fix it; and each additional direction from a known point gives a side-equation; if, at the new point two independent angles between these directions are observed, each such angle gives a new equation.

C. R. C.

APPENDIX D.

LENGTHS OF THE FIVE NEW LAKE-SURVEY YARDS.

The five new lake-survey yards are marked L. S. No. 6, 7, 8, 9, 10. They are bronze bars, one inch wide by sixth-tenths of an inch thick, having cylinders four-tenths of an inch in diameter at each end, bearing agates ground to a radius of four inches. The extreme points of the agates are approximately one yard apart, and project with their cylinders six-tenths of an inch beyond the ends of body of yards.

The two new yards of the Office of Weights and Measures, with which the lake-survey yards were compared, are called "Transfer Yards A and B," and are like the former in every respect, save that at the middle of their lengths a small well is bored to the middle of their thickness, and at the bottom of the well there is a fine line engraved on a small silver surface. The object of this line is the ready microscopic comparison of the lengths of these two end-measure yards with the British standard-yards, bronze No. 11 and malleable iron No. 57, in possession of the Office of Weights and Measures, these latter being line-measure yards.

The microscopic comparison of No. 11 with the distance between the two lines in the wells of A and B when they are arranged in line and in contact, in the four different possible orders, gives at once the lengths of A and B in terms of No. 11.

In determining the values of A and B in terms of British bronze No. 11, (A+B) was determined on the new microscopic comparator of the Office of Weights and Measures by Mr. Lane, and Mr. Hilgard gives as the probable error of the resulting value of (A+B) 0.000014 inch.

The value of (A—B) is 0.000891 inch, and was determined on the Saxton's pyrometer. Mr. Hilgard does not attempt to assign the probable error of this value, which must be much less than that of (A+B).

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Mr. Hilgard gives as the result of comparisons of transfer-yards A and B with British bronze No. 11, the temperature being 61.79 F, at which No. 11 is a British yard.

A = No. 11 + 0.0009197 inch.
B = No. 11 + 0.0000285 inch.

Taking the co-efficient of expansion of A and B as 0.0000097, which Mr. Hilgard thinks it does not exceed, we have for lengths of A and B at 62° F., denoting one British yard by Y.

A at 62° F = Y + 0.000993 inch.
B at 62° F = Y + 0.000102 inch.

The comparisons of L. S. yards Nos. 6, 7, 8, 9, 10, with A and B were made on the Saxton's pyrometer of the Office of Weights and Measures, at temperatures varying from 55° to 64°.5 F.

They are made of the same material as A and B, and their comparison with our 15-foot bar shows that they differ in co-efficient of expansion very slightly, if at all, from the value given above for A and B.

If we assume their co-efficients of expansion the same as those of A and B within the range of comparison, the following values for their lengths result, from the comparison thus far made. These results must only be considered as preliminary, as further comparisons will be made.

At 62° L. S. No. 6 = Y + 0.00002 inch.
At 62° L. S. No. 7 = Y + 0.00133 inch.
At 62° L. S No. 8 = Y + 0.00002 inch.
At 62° L. S. No. 9 = Y + 0.00159 inch.
At 62° L. S. No. 10 = Y + 0.00155 inch.

Lake-survey yards Nos. 6 and 7 were compared with each of A and B, and on more than one day and combining the comparisons by least squares, the probable error of the resulting values of 6 or 7 in terms of A or B is found to be 0.00001 inch. L. S. yards 8, 9, and 10 were less carefully compared, and will be again compared with Nos. 6 and 7. Mr. Hilgard's letter is appended:

"UNITED STATES COAST SURVEY OFFICE,
"*Washington, April* 22, 1872.

"DEAR SIR: I am at last enabled to give you the result of the comparison of the two 'well' yards, or 'transfer yards' as we have now called them, with the British standard.

"The one formerly designated as 101 we have called A.

"The one formerly designated as blank we have called B.

"We find that A + B = twice the British bronze yard No. 11 + 0.000948 in. at the temperature of 61°.8 at which the latter is standard. From a comparison of the 74 complete observations made, at temperatures ranging from 42° F. to 73° F., including 20 near the standard temperature, a probable error of ±0.000014 in. may be ascribed to this value, or ±0.000010 in. for one yard. I would not, however, draw the limits of precision so close until verified by observations in different years.

"The comparisons of A and B were made on the pyrometer, the bars being supported in precisely the same manner as in the line comparisons. Observations were made on thirteen days at temperatures ranging from 50°.1 F. to 62°.9 F. No difference depending on temperature could be discovered.

"The contacts were re-adjusted every day, and the ends interchanged. The probable error of one day's result is but $\frac{1}{1000}$ of an inch. I do not attempt to assign that of the mean value, which is A — B = 0.0008912 in.

"We have, therefore, A = Br. yard No. 11 + 0.0009197 in.
B = Br. yard No. 11 + 0.0000285 in.

"Full experiments for the dilatation of the brass yards remain to be made. The following data may be useful in the mean time. The comparisons with the bronze yard above referred to show an increase in the length of the brass yard over that of the bronze standard of 0.0000049 in. for 1° Fahr., and as the expansion of the bronze bar is stated at 0.000342 in. for each degree, that of the American yard becomes 0.0003469 in.

"Similarly we have found from comparison of between temperatures 61° and 80° the iron meter with a brass one of the same metal as the yards, an increase of expansion of 0.0001301 in. over that of the iron for 1°; taking the proportional expansion of the latter at 0.00000642, we find for that of the brass bar 0.00000973. The preceding value corresponds to 0.00000964. Mr. Hassler found 0.00001051, but in order to bring Mr. Hassler's value of the meter observed at 32° to Clark's value at 62° we must allow a proportional expansion of 0.00000962 for the Troughton scale, the expansion of which has not been found to differ visibly from that of our yards. It appears probable that the co-efficient of expansion of the yards does not exceed 0.0000097.

"Yours, respectfully,

"J. E. HILGARD,
"*Assistant in Charge.*

"General C. B. COMSTOCK,
"*Superintendent United States Lake Survey, Detroit.*"

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APPENDIX E.

OFFICE UNITED STATES LAKE SURVEY.
January 16, 1872

MAJOR: In obedience to your orders, I have the honor to submit the following re upon the constants and errors of the new Troughton & Simms repeating theod This instrument has a horizontal and a vertical limb, each 12 inches in diameter graduated to five minutes. The horizontal limb is read to single seconds by two opp site reading-microscopes. The vertical limb is read to five seconds by two oppo verniers. The telescope has a 2-inch object-glass, and a focal length of 18.7 inches is provided with an illuminating axis-lamp, one diagonal and two direct eye-pie The outer vertical axis carries the horizontal limb, is 4.2 inches long, and has a dia ter of 1.3 inches at the upper, and 1.2 inches at the lower end. It fits into a tripod rests upon a shoulder at its upper end. The shoulder is $\frac{3}{10}$ inch wide. There means of adjusting this axis so as to make it fit tighter or looser in the tripod present it fits perfectly. Both axis and tripod are of brass. The inner axis carries telescope and reading microscopes, is of steel, 5 inches long, diameter at upper en inch, at lower end $\frac{6}{10}$ inch. The lower end rests upon an adjustable plate, so that can be raised or lowered. This axis was broken last summer while the instrument was being transported from this office to Green Bay, Wisconsin. A new one has been m by Würdemann.

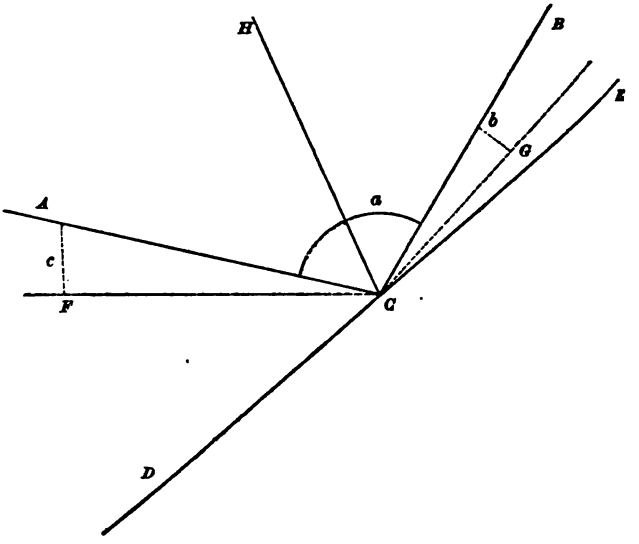
During the examination the instrument was mounted on one of the stone posts the observatory.

The value of a division of the level on the vertical limb was found by comparing with the level belonging to astronomical transit No. 15 (Würdemann.) The m of 44 level readings gave a value of 2″.24. The same result was obtained by com ing it with the vertical limb. The value of a division of the axis or striding level found in the same way. The mean of 36 level readings gave a value of 1″.05 for division.

The angle which the two axes make with each other was found in the follow manner:

The inner axis was clamped to the outer one and the level read. Both axes then revolved 180° and the reading repeated. This eliminates the error of level gives the inclination of the outer axis in the direction of the level. This was repea ten times and a mean taken. The outer axis was then clamped to the tripod and inclination of the inner axis found in the same way and for the same direction. T difference of these two inclinations is the angle which the axes make with each in the direction of the level.

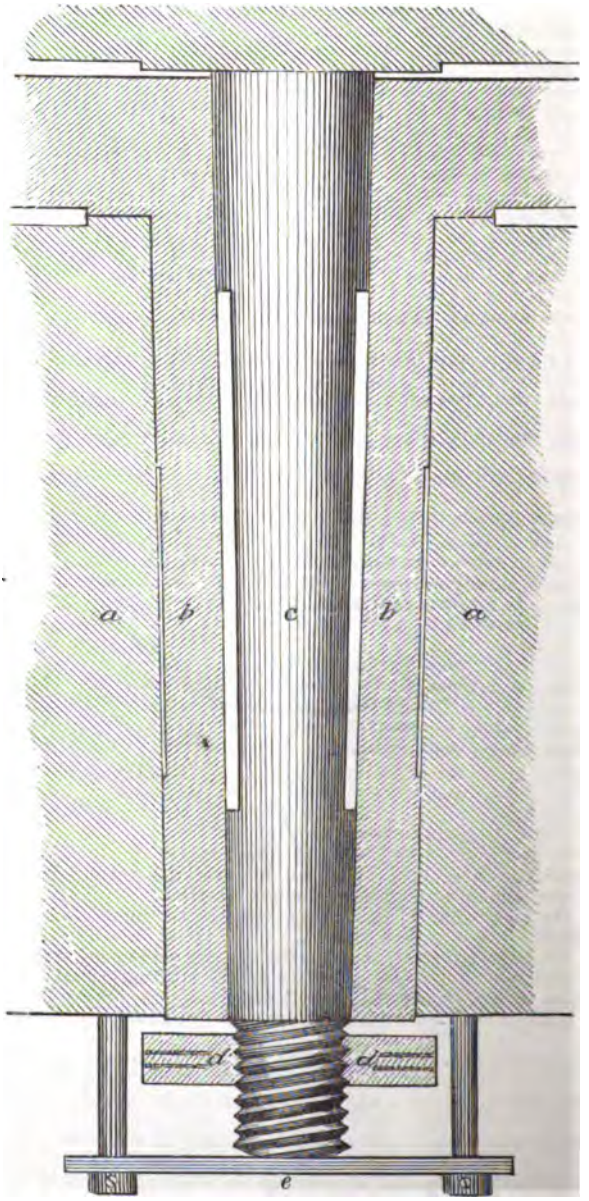
The level was next placed in a new position, 120° from the first, and the oper repeated. If the outer axis is perpendicular, then these differences are the devia of the inner axis from the vertical. If the level be at right angles to the inner a these differences are the deviations of the level from a horizontal plane. The where the deviation is a maximum and the maximum deviation can be computed the following method:



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Sketch of the two vertical axes, full size,



a, a, section of brass tripod; *b, b*, section of outer axis; *c*, inner axis; *d, d*, nut-securing axis; *e*, adjustable plate for raising or lowering inner axis.

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Let $C\ A$ be the first position of the level; $C\ F$ its horizontal projection; $C\ B$ second position of level; $C\ G$ its horizontal projection; a = angle between first and second position; c = deviation for first position; b = deviation for second position.

There is one position in which the deviation of the level will be zero.

Let D E be that position:

Then—

$$\sin c : \sin b :: \sin A\,C\,D : \sin B\,C\,E$$

but—

$$B\,C\,E = 180^\circ - a - A\,C\,D$$

Hence—

$$\sin c \sin (180^\circ - a - A\,C\,D) = \sin b \sin A\,C\,D$$

or,

$$\sin c \sin (180^\circ - a) \cos A\,C\,D - \cos (180 - a) \sin A\,C\,D = \sin b \sin A\,C\,D$$

Dividing by sin A C D it becomes—

$$\sin c \sin (180^\circ - a) \cot A\,C\,D - \cos (180^\circ - a) = \sin b$$

or,

$$\cot A\,C\,D = \frac{\sin b + \cos (180^\circ - a)}{\sin c \sin (180^\circ - a)}$$

a, b, and c being known, the angle A C D becomes known, which gives the position of D E, or the line of no deviation. The maximum deviation is at right angles to D E, or on the line of C H. To find maximum deviation,

$$\sin A\,C\,D : \sin H\,C\,D \text{ or } 90^\circ :: \sin c : \text{sin of maximum deviation, or}$$

$$\text{sin of maximum deviation} = \frac{\sin 90^\circ \sin c}{\sin A\,C\,D}$$

Usually b and c are so small that the angles themselves can be used instead of their sines.

The level was read in third position, and the deviation thus obtained compared with the computed deviation for a check upon the work.

Three separate determinations, requiring 464 level-readings, were made with the following results:

First determination gave angle between two axes	7″.8
Second determination gave angle between two axes	5″.9
Third determination gave angle between two axes	5″.9
Mean	6″.5

The line on which the horizontal projection of the inner axis falls when the outer axis is vertical:

First determination from center of limb to	216°
Second determination from center of limb to	207°
Third determination from center of limb to	193°
Mean	205°

The reason that the first result differs so much from the second and third is probably because its level-readings were taken with an interval of five hours between them, during which time the stone-post may have changed position.

The angle which the outer vertical axis makes with the horizontal limb was found in the following manner:

The deviation of the outer axis was found in the manner previously described. The outer axis was then removed and a steel rule laid on the horizontal limb.

The level was then placed on the rule and readings taken as before, the rule being reversed in each position to eliminate the difference in thickness between its two ends.

The computations were made as before. Sixty-four level-readings gave the following result:

The angle between the outer axis and its projection on the horizontal limb = 89° 59′ 48″.1—.

The horizontal projection of the outer axis falls on the line from the center of limb to 44°.

The eccentricity of both limbs was determined by readings every 30° around the limb, each reading being repeated four times and a mean taken.

The eccentricity was then computed by the formulæ given in Chauvenet.

The following are the results:

Eccentricity of horizontal limb	1″.5
Eccentricity of vertical limb	1″.9
The line joining centers of horizontal limb and inner axis passes through	56°

The line joining centers of vertical limb and of alidade passes through 15°; angular

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distance between microscopes, 179° 59′ 54″.4; angular distance between verniers on the vertical limb, 179° 59′ 58″.

The horizontal axis was tested by reading the striding-level at ten different elevations of the telescope's axis.

The readings were repeated four times and a mean taken.

The result shows the irregularities to be less than the errors of level-readings.

The difference in the diameters of the ends of the horizontal axis was found by reversing the axis in its supports and reading the level in both positions.

The mean of twelve trials gave a change of 6.2 divisions of the level, the illuminating end being the smallest.

The angles of the level and axis V's are equal; therefore, dividing 6.2 divisions by 4 gives 1.55 divisions, or 1″.627, which is the correction for inequality of ends of axis. When the instrument is used for an astronomical transit and the illuminating end of the axis is west, this correction should be added to the elevation of the west end of the axis as given by the level.

The graduation of the horizontal limb has been tested in three ways:

1. By computing, with the eccentricity, the readings of opposite microscopes: (with Chauvenet's formula) and comparing them with the observed readings. The maximum difference found in this way was 2″.5; the average difference being 1″.1, which is about the same as the errors of reading.

2. By measuring the space between two consecutive divisions with the micrometer, the greatest difference found being 0″.5.

3. By placing two collimators on the same post and repeating the angle between them.

No satisfactory results were obtained by this method, owing to the unsteadiness of the collimator-posts. The focal length of the telescope is 18.7 inches. Dividing by 10 inches, the power of the object-glass alone is found to be 1.87 diameters.

The power of the telescope, in combination with each of its eye-pieces, was measured with Ramsden's dynameter, and found to be, for the diagonal eye-piece, 35 diameters; for the direct eye-pieces, 35 and 24 diameters.

The microscopes for reading the horizontal limb and the magnifiers for reading the vertical limb were used as eye-pieces in the telescope, and the power of the combination measured with the dynameter.

The microscopes gave a power of 94 diameters, which, divided by the power of the object-glass, (1.87,) shows the power of the microscopes alone to be 50 diameters.

The power of the magnifiers for the vertical circle was found in the same way to be 7 diameters.

The power of the microscopes was again found by placing two similar scales so that one was in the focus of the microscope and the other 10 inches from the eye; then looking at both at the same time, one division of the magnified scale covered 55 divisions of the other scale, indicating a power of 55 diameters in the microscope. With high powers the error by this method may be 4 or 5 diameters. The first method is much more exact.

The power of the magnifiers being low, both methods gave it the same.

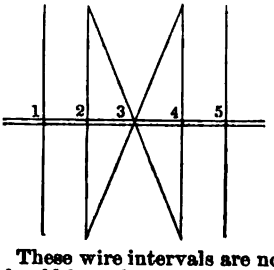
A number of five-minute divisions on different parts of the limb were measured with microscope B. The mean was 4 revolutions, 59.2 divisions.

The readings of this microscope should, therefore, be multiplied by 1.0027, to reduce them to minutes and seconds.

In a similar way it was found that the readings of microscope A should be multiplied by 1.0069.

There are four vertical, two horizontal, and two oblique spider-lines in the telescope. The two oblique lines are nearly vertical, crossing each other in the center of the field. For transit-work their intersection can be used for the middle line.

The intervals between the lines were found by bringing each line separately to coincide with the spider-line of the collimator, reading the angle from the horizontal limb of the theodolite. The vertical angle being zero, no corrections were required. The lines are numbered from the illuminating end of the axis.



The mean of 60 observations gave the interval from 1 to 2	14°.67
The mean of 60 observations gave the interval from 2 to 3	15°.03
The mean of 60 observations gave the interval from 3 to 4	14°.83
The mean of 60 observations gave the interval from 4 to 5	14°.44
The mean of 60 observations gave the interval from 1 to 5	58°.97

These wire intervals are not satisfactorily determined. Before being adopted they should be redetermined by some other method.

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The error of reading a single microscope was found by reading the microscope upon a division of the limb, then turning it off, bringing it back, and reading a second time. Twenty-one trials showed the average difference of a single observation, from the mean of all, to be 0″.3.

The error of a single pointing was found by bringing the spider-line of the telescope upon that of the collimator and reading both microscopes; the telescope was then turned slightly in azimuth and both micrometers turned part of a revolution.

The telescope and micrometers were then brought back as near as possible to the original position and read a second time. The difference in the two readings is the combined error of pointing and reading. Twenty trials showed the average difference of a single pointing, from the mean of all, to be 0″.4.

The repeating powers of the telescope were tested by repeating the angle between two collimators standing on the same post. It was found that passing street-cars and heavily loaded wagons jarred the collimators so as to make permanent changes in the angles. This test was therefore valueless. A large astronomical transit was next used for a collimator, and the angle between the outside spider-lines was measured. The mean difference of a single pointing from the mean of all was 1″.1. The mean difference of a set of five repetitions from the mean of all was 0″.3. These quantities, of course, vary with the observers, and the conditions of light, steadiness, &c. They show approximately how much of the error in actual work should be attributed to the instrument and observer and how much to phase, horizontal refraction, twist of post, &c.

During the examination of this instrument there have been no defects of any magnitude discovered. The errors of eccentricity, ellipticity, and graduation are small The material and workmanship of the construction are of the best quality.

SUMMARY OF RESULTS.

Value of one division of striding-level	1″.05
Value of one division-level on verticle circle	2″.24
Wire intervals from 1 to 2	14ˢ.19
Wire intervals from 2 to 3	15ˢ.03
Wire intervals from 3 to 4	14ˢ.83
Wire intervals from 4 to 5	14ˢ.44
Angle between outer axis and its projection on horizontal limb	89° 59′ 48″.1
Projection of outer axis on horizontal limb falls on the line from center of limb to	44°
Angle between two vertical axes	6″.5
Projection of inner axes on horizontal limb, when outer axis is vertical, falls on the line from center of limb to	205°
Eccentricity of horizontal limb	1″.5
Line through centers of limb and inner axis passes through	56°
Angular distance between microscopes	179° 59′ 54″.4
Eccentricity of vertical limb	1″.9
Line through centers of limb and alidade passes through	15°
Angular distance between verniers	179° 59′ 58″
Co-efficient for correction of micrometer A	1.0069
Co-efficient for correction of micrometer B	1.0027
Axis correction, 1.55 division of level, or	1″.627
Power of telescope with diagonal eye-piece	35 diameters.
Power of telescope first direct eye-piece	35 diameters.
Power of telescope, second direct	24 diameters.
Power of reading-microscopes	50 diameters.
Power of magnifiers on vertical circle	7 diameters.
Maximum error found in graduation	2″.5
Mean error of single reading of microscope	0″.3
Mean error of single pointing at some object	0″.4
Mean error of single measurement of an angle	1″.1
Mean error of five repetitions	0″.3

Very respectfully, your obedient servant,

E. S. WHEELER,
Assistant United States Lake Survey.

General C. B. COMSTOCK,
Major of Engineers.

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APPENDIX F.

UNITED STATES NAVAL OBSERVATORY.
Washington, October 26, 1871.

SIR: I herewith inclose a description of the instruments used in the observations to determine the clock-corrections employed in the determination of the difference of longitude between Detroit and the United States Naval Observatory, together with the deduced clock-corrections and rates.

The observations were made with the transit-instrument, which is mounted in the east wing of the Observatory, 42.9 feet (0s.036) east of the center of the dome. This instrument has a focal length of 84.4 inches, and an aperture of 5.33 inches. The system of transit-threads is divided into five sets, known as sets A, B, C, D, and E, and the following table, derived from observations by Professor M. Yarnall, United States Navy, in 1871, shows the reduction for each wire to the mean of sets B, C, and D, when the clamp of the instrument is east:

s.	s.	s.	s.	s.
$A_1 + 37.897$	.....	$C_1 + 3.183$	$D_1 - 15.146$	$E_1 - 30.003$
$A_2 + 35.972$	.....	$C_2 + 1.654$	$D_2 - 17.589$	$E_2 - 32.647$
$A_3 + 34.308$	$B_1 + 19.216$	$C_3 + 0.014$	$D_3 - 19.110$	$E_3 - 34.153$
$A_4 + 32.745$	$B_2 + 17.563$	$C_4 - 1.639$	.....	$E_4 - 35.820$
$A_5 + 30.205$	$B_3 + 15.069$	$C_5 - 3.221$	.....	$E_5 - 37.693$

The observations were recorded on the cylinder-chronograph, which has been in use at the Observatory for many years by means of make-circuit signals in the usual way. The clock (a Charles Frodsham) records each beat on the chronograph except the sixtieth second of each minute, which, for the convenience of fixing the position of the beginning of each minute on the sheet, is omitted by means of a small arm, which, revolving on the shaft of the escapement-wheel of the clock, prevents the closing of the circuit at that instant by the clock.

The corrections to the observed transit of a star were derived from the observed errors represented by c', n', and m'; c' represents the error of collimation, n' the equatorial value of the distance between the plane of collimation and the true meridian at the pole, and m' the distance between the plane of collimation and the true meridian at the equator.

The quantities represented by n' and m' are used instead of errors of azimuth and level.

By means of a collimating eye-piece, the error of collimation and level was obtained by reversing the instrument over a basin of mercury and measuring with the right-ascension micrometer the distance between the central thread and its image reflected from the mercury. Letting c, n, and m represent the corrections obtained from the observed and computed errors c', n', and m';

$2\,\Delta$ the distance of the central thread west of its image when the clamp-end of the axis is east;

$2\,\Delta'$ the distance of the central thread west of its image when the clamp-end of the axis is west;

p the correction for the excess of the radius of the clamp pivot $= 0^s.008$;

τ the reduction of the mean of sets B, C, and D to the middle thread $= 0^s.014$;

a the correction for diurnal aberration $= -0^s.016$;

b the level correction;

α the American Nautical Almanac's place of the star;

α' the observed place of the star;

c' the approximate clock correction;

c the clock correction for each star;

and we have the following formulæ, which have been employed in determining the clock-corrections from the observations of each star:

$$c = \tfrac{1}{2}(\Delta - \Delta') - p - \tau + a, \text{ clamp east.}$$
$$c = -\tfrac{1}{2}(\Delta - \Delta') + p + \tau + a, \text{ clamp west.}$$
$$b = -\tfrac{1}{2}(\Delta + \Delta') - p, \text{ clamp east.}$$
$$b = -\tfrac{1}{2}(\Delta + \Delta') + p, \text{ clamp west.}$$
$$n = a - \frac{(\alpha' + c' + c \sec \delta)}{\sec \delta}$$
$$m = -n \tan \phi + b \sec \phi$$
$$c = \alpha - (\alpha' + m + n \tan \delta + c \sec \delta)$$

ϕ, representing the latitude of the observing station $= 38° 53'.65$.

One revolution of the right-ascension micrometer-screw $= 1^s.5865$.

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The following table shows the date, name of object, and all the reductions for each star observed on the 19th, 23d, and 24th May:

No.	Date.	Object.	Mean of transits reduced to mean of sets B, C, and D.	Correction.			Observed right ascension.	Nautical Almanac's right ascension.	Clock-correction.
				Δc	Δn	m			
	1871.		h. m. s.	s.	s.	s.	s.	h. m. s.	s.
1	May 19	ϵ Bootis	14 39 23.20	+0.12	+0.10	−0.14	23.28	14 39 22.66	− 0.62
2		β Bootis	14 57 7.42	+0.13	+ .16	.14	7.57	14 57 6.91	− 0.66
3		β Libræ	15 10 6.17	+ .10	— .03	.14	6.10	15 10 5.42	− 0.68
4		μ^1 Bootis	15 19 39.25	+ .13	+ .14	.14	39.38	15 19 38.77	− 0.61
5		α Coronæ Borealis	15 29 15.70	+ .11	+ .09	.14	15.76	15 29 15.11	− 0.65
6		α Serpentis	15 37 56.96	+ .10	+ .02	.14	56.94	15 37 56.27	− 0.67
7		ϵ Serpentis	15 44 25.20	+ .10	+ .01	.14	25.17	15 44 24.62	− 0.55
8		δ Aquilæ	19 19 1.42	+ .10	+ .01	.14	1.39	19 19 0.52	− 0.87
9		κ Aquilæ	19 29 58.79	+ .10	— .02	−0.14	58.73	19 29 57.89	− 0.84
10		γ Aquilæ	19 40 9.25	+0.10	+0.03	−0.14	9.24	19 40 8.43	− 0.81
11		α Aquilæ	19 44 30.99	+ .10	+ .03	.14	30.98	19 44 30.15	− 0.83
12		β Aquilæ	19 49 0.16	+ .10	+ .02	.14	0.14	19 48 59.36	− 0.78
13		λ Ursæ Minoris	19 53 42.16	+5.31	+9.56	.....	57.03	19 53 56.20	.....
14	May 23	η Herculis	16 38 27.51	− .15	+ .07	.05	27.38	16 38 30.22	+ 2.84
15		κ Ophiuchi	16 51 32.59	− .12	+ .01	.05	32.43	16 51 35.16	+ 2.73
16		d Herculis	16 56 49.55	− .14	+ .06	.05	49.42	16 56 52.14	+ 2.72
17		α^1 Herculis	17 8 44.74	− .12	+ .02	.05	44.59	17 8 47.38	+ 2.79
18		δ Ursæ Minoris	18 14 14.18	−2.26	+1.49	.....	13.41	18 14 16.13	.....
19		δ Aquilæ	19 18 58.17	− .11	.00	.05	58.01	19 19 0.63	+ 2.62
20		γ Aquilæ	19 40 6.03	− .12	+ .02	.05	5.88	19 40 8.54	+ 2.66
21		α Aquilæ	19 44 27.72	− .12	+ .01	.05	27.56	19 44 30.26	+ 2.70
22		β Aquilæ	19 48 57.00	− .12	+ .01	.05	56.84	19 48 59.47	+ 2.63
23		τ Aquilæ	19 57 48.51	− .12	+ .01	.05	48.35	19 57 51.13	+ 2.78
24	May 24	α Serpentis	15 37 54.25	− .11	+ .01	.01	54.14	15 37 56.31	+ 2.17
25		ϵ Serpentis	15 44 22.64	− .11	+ .01	.01	22.53	15 44 24.68	+ 2.13
26		ϵ Coronæ Borealis	15 52 14.44	− .12	+ .04	.01	14.35	15 52 16.49	+ 2.14
27		δ Ophiuchi	16 7 34.69	− .11	— .01	.01	34.56	16 7 36.65	+ 2.09
28		δ Ursæ Minoris	18 14 14.66	−1.89	+1.38	.....	14.15	18 14 16.26	.....
29		α Lyræ	18 32 33.66	− .14	+ .07	.01	33.58	18 32 35.77	+ 2.19
30		β Lyræ	18 45 18.37	−0.13	+0.05	− .01	18.28	18 45 20.40	+ 2.12

Collimation.

May 19.9. Image east, 0r.16; clamp east.
May 19.9. Image west, 0r.19; clamp west.
May 23.9. Image west, 0r.17; clamp west.
May 24.9. Image west, 0r.19; clamp west.
May 24.9. Image east, 0r.10; clamp east.

During the observations on the 19th the clamp was east, but it was west on the 23d and 24th.

Values of constants.

	c	n	m
May 19.	+ 0s.102	+ 0s.184	— 0s.143
May 23.	— 0s.114	+ 0s.088	— 0s.046
May 24.	— 0s.110	+ 0s.082	— 0s.010

From the clock corrections derived from each star, the following *corrections* and *rates* have been deduced by the method of least squares.

Date.	Sidereal time.	Correction.	Rate.
	h. m. s.	s. s.	s.
May 19	14 0 0	− 0.587 ± 0.009	−0.0411
May 23	16 0 0	+ 2.794 ± 0.013	−0.0377
May 24	15 0 0	+ 2.130 ± 0.010	+0.0053

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A preliminary reduction of the *complete* observations for *personal equation* has been made, from which it seems that but little confidence can be placed in the results of such observations, since they differ widely on different nights.

If, upon the final reduction, any new light is obtained, I will immediately forward the result to you.

Very respectfully, &c., yours,

B. F. SANDS.
Rear-Admiral, Superintendent.

General C. B. COMSTOCK, U. S. A.,
Superintendent U. S. Lake Survey, Detroit, Michigan.

APPENDIX G.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, June 21, 1872

GENERAL: In compliance with your instructions I have the honor to submit the following report on the preparations for and the reduction of observations for determining the difference of longitude between the observatories of the lake survey at Detroit, Michigan, and Duluth, Minnesota, and between that at Duluth and that at Saint Paul, Minnesota.

Early in the season of 1871 preparations were made for this telegraphic connection. It was not, however, until June that the observers were in readiness to occupy the stations you assigned them; yourself, aided by Assistant G. Y. Wisner, with Mr. R. Woodward as recorder, to observe at Duluth; Assistant A. R. Flint, with Mr. J. C. Jones as recorder, to observe at Saint Paul; and myself, with Sub-Assistants Thomas Russell and C. F. Burton as recorders, to observe at Detroit.

The two sidereal clocks (Nos. 184 and 256) and two chronographs (Nos. 216 and 25 of the Lake Survey, made by William Bond & Son, Boston, were assigned to the extremities of the line at Detroit and Duluth, Nos. 184 and 216 being used at Detroit. At Saint Paul sidereal chronometer No. 176, William Bond & Son, and mean-time chronometer No. 4212, Adams, were used. The transits used were, at Detroit, one known as the old Troughton & Simms, the focal length of its object-glass being 43 inches, and with eye-piece magnifying 110 diameters, and at Saint Paul and Duluth Nos. 1 and 15, Würdemann, respectively, the focal length of each being 32 inches and with eye-piece magnifying 65 diameters.

The preparations made were the mounting of the astronomical instruments at Detroit on stone piers on a new site, the former observatory having been taken down in March, 1870; an examination of the portable instruments proposed to be used; and observations for personal equation. Also a stone pier was prepared for the mounting of the transit at Duluth.

At Saint Paul the transit was mounted on a stone and mortar pier, built up from the foundation-rock. The observatories were situated as follows: At Detroit the east transit pier used in this connection is 143.7 feet (or 0ˢ.127) west and 146.6 feet (or 1″.45) north from the west transit pier of the old observatory. The east pier, above mentioned, is also 321.0 feet west and 294.0 feet north from the southwest corner of the stone foundation of the Westminster church on Washington avenue. At Duluth the transit pier was 150.1 feet (or 0ˢ.143) east and 110.25 feet (or 1″.08) north from the primary triangulation station, north base on Minnesota Point. At Saint Paul the transit pier was 451.3 feet (or 0ˢ.418) east and 48.4 feet (or 0.″48) south from the southeast corner of the new custom-house on Wabashaw street.

A double telegraph-line was put up, connecting the observatory at Detroit with the main office, a distance of three-fourths of a mile; and at Duluth, a single line, with ground-connection at the observatory, was built for the distance of two and one-fourth miles to connect with the office at Duluth. At Saint Paul the observatory was near the telegraph-office, and a loop of wire was put in connecting the two. The circuit was formed by way of Chicago, Milwaukee, and Saint Paul, with repeaters at Chicago and Saint Paul. The table of distances is as follows:

	Miles.
Detroit to Chicago	284
Chicago to Milwaukee	[illegible]
Milwaukee to Saint Paul	307
Saint Paul to Duluth	154
Total	922

The work was much delayed, owing to unfavorable weather and failures in the telegraphic connections. The successful nights between Detroit and Duluth were

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June 15 and 26, and July 11, on the former of which at Duluth you were the observer, and on the latter two Assistant Wisner was the observer. Between Duluth and Saint Paul, the successful nights were June 14 and 15, on both of which you were the observer at Duluth. From observations made on nights when comparisons of time between stations were unsuccessful, and also from special observations, the wire intervals of each instrument were tested or redetermined. The inequality of pivots and values of levels were also redetermined.

The method employed was that by transmission of clock-signals. The clock-signals between Detroit and Duluth being automatic, the two clocks were compared by connecting first one and then the other with the telegraph-wire, and thus causing them both to record their beats simultaneously, first upon the chronograph at one station and then upon that at the other.

Between Duluth and Saint Paul the clock-signals were automatic only in one direction, and the comparisons were made by the observer at Saint Paul, noting on a mean-time chronometer coincident beats with the automatic clock-signals from Duluth, comparisons in the opposite direction being made by the observer at Saint Paul, striking on the break-circuit key in unison with his mean-time chronometer, thus recording the seconds on the Duluth chronograph. By the use of signals transmitted in both directions, the wave-time and loss of time in the use of repeaters becomes practically eliminated. The errors and rates of the clocks and the relative personal equation of the observers being determined, the correct difference of time between the two stations thus becomes known.

Where the chronograph was used at Detroit and Duluth generally fifteen wires were observed on each star, but nine only were used as constituting a complete observation. At Saint Paul the observations were by eye and ear, and only five wires were observed. Duplicate readings from the chronographic records were made and the readings compared.

Two determinations of the clock corrections in each case were made entirely independently by two computers and by different methods: the one by high and low stars, the other by the method of least squares. In several cases also a second computation by the method of least squares was made, rejecting a few stars whose residuals were large in the first computation. In all cases the rejected stars are herewith given, and generally a sufficient reason given for their rejection.

The reduction by the method of least squares is the one here given. With one exception the collimation has been determined by reversal on close polar stars and not included in the equations of condition. The rate has generally been included in the equations as an unknown quantity. In a few cases a sudden change of azimuth has been suggested by the observations and a new unknown quantity for azimuth has been introduced and determined from the equations. There is in general noticeable a gradual change in azimuth at night from the south toward the west of south, or in the direction opposite to that in the twist of stations by day, as frequently noticed in the reading of horizontal angles.

At Detroit on the 15th three stars, *θ Bootis*, *τ Herculis*, and *η Herculis*, all very near the zenith, were rejected, and the tortuous position in observing affords a sufficient reason for rejecting them. On the 26th *τ Herculis* in the zenith, and *d Sagitarii* of very low altitude, and on July 11th *η Herculis*, *a Cygni*, and *ν Cygni*, near the zenith, and *β Aquilæ* and *a*² *Capricorni* were rejected. At this station the observatory is situated near a paved street, on which loaded wagons and street-cars are passing until a late hour. On this account there are fewer observations, since it was necessary to commence late, and probably the observations made are more discordant than they otherwise would have been. At Duluth only one star, *θ Bootis*, on the 15th, being near the zenith, was rejected.

At Saint Paul, on the 14th, two stars were rejected, *a Bootis* and *d Herculis*, there being but three wires observed, and these being discrepant. On the 15th *τ Herculis*, near the zenith, and *a* Coronæ Borealis were rejected. The results for clock corrections and rate at the three stations on the several nights, taken from the tables appended to this report, are as follows:

Detroit clock correction and rate.

Date.	By clock No. 184.	Clock correction.	Hourly rate.
	h. m.	m. s. s.	s.
June 15, 1871	17 47	− 1 24.87 ± 0.030	+ 0.088
June 26, 1871	18 04	− 1 28.55 ± 0.020	− 0.053
July 11, 1871	18 24	− 1 04.08 ± 0.021	− 0.084

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Duluth clock correction, (the rate being essentially zero.)

Date.	By clock No. 256.	Clock correction.
	h. m.	s. s.
June 14, 1871	17 00	− 38.59 ± 0.012
June 15, 1871	18 00	− 38.34 ± 0.015
June 26, 1871	17 00	− 39.02 ± 0.012
July 11, 1871	18 30	− 28.41 ± 0.010

Saint Paul sidereal chronometer—correction and rate.

Date.	By chronometer No. 176.	Chronometer correction.	Hourly rate.
	h. m.	s. s.	s.
June 14, 1871	16 05	− 8.30 ± 0.012	+ 0.154
June 15, 1871	15 51	− 8.74 ± 0.017	− 0.022

Saint Paul mean-time chronometer—direct comparison with sidereal chronometer, resulting correction to sidereal time, and rate on sidereal time for a sidereal hour.

Date.	By coincidences.		Resulting correction to No. 4212.	Hourly rate.
	No. 4212.	No. 176.		
	h. m. s.	h. m. s.	h. m. s.	s.
June 14, 1871	8 18 20.0 =	13 47 07.0	+ 5 28 39.05	− 9.435
	14 14 57.5 =	19 44 42.0	+ 5 29 35.64	
June 15, 1871	10 03 29.0 =	15 36 25.5	+ 5 32 47.76	− 9.486
	12 50 52.0 =	18 24 15.0	+ 5 33 14.32	

The comparisons of clocks and the resulting differences of longitude uncorrected for personal equation, omitting probable errors, are as follows:

Detroit and Duluth—direct comparisons of clocks, being the mean of one hundred and twenty-one consecutive second-breaks from each record.

Date.	Duluth chronograph.		Detroit chronograph.	
	Clock No. 184.	Clock No. 256.	Clock No. 184.	Clock No. 256.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
June 15, 1871	18 42 14.59 =	18 05 22.00	18 21 33.00 =	17 44 40.72
June 26, 1871	18 33 00.51 =	17 56 05.00	18 30 16.00 =	17 53 20.75
July 11, 1871	19 07 27.65 =	18 30 46.00	19 20 29.00 =	18 43 47.59

The same as above, with errors of clock applied.

Date.	Duluth chronograph.		Detroit chronograph.	
	Clock No. 184.	Clock No. 256.	Clock No. 184.	Clock No. 256.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
June 15, 1871	18 40 49.64 =	18 04 43.66	18 20 08.08 =	17 44 02.38
June 26, 1871	18 31 31.94 =	17 55 25.98	18 28 47.43 =	17 52 41.73
July 11, 1871	19 06 23.51 =	18 30 17.59	19 19 24.84 =	18 43 19.18

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Detroit and Duluth—difference of longitude.

Date.	From Duluth record.	From Detroit record.	Mean.	Wave and armature time.
	m. s.	m. s.	m. s.	s.
June 15, 1871	36 05.98	36 05.70	36 05.84	0.140
June 26, 1871	36 05.96	36 05.70	36 05.83	0.130
July 11, 1871	36 05.92	36 05.66	36 05.79	0.130

Duluth and Saint Paul—direct comparison of clock and mean-time chronometer, being at Duluth, for each comparison, the mean of 79 consecutive second-breaks of the mean-time chronometer as recorded on the chronograph, and at Saint Paul coincidences of clock and chronometer.

Date.	Duluth chronograph.		Coincidences at Saint Paul.	
	Clock No. 256.	Chron. No. 4212.	Clock No. 256.	Chron. No. 4212.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
June 14, 1871	18 56 49.82	= 13 22 40.0	18 36 13.0	= 13 02 06.5
	19 03 00.78	= 13 28 50.0	18 42 16.0	= 13 08 08.5
June 15, 1871	18 46 49.15	= 13 08 50.0	18 30 12.0	= 12 52 15.5
			18 33 02.0	= 12 55 05.0
			18 36 08.0	= 12 58 10.5
			18 39 06.0	= 13 01 08.0

The same as above, with errors of clock applied.

Date.	Duluth chronograph.		Coincidences at Saint Paul.	
	Clock No. 256.	Chron. No. 4212.	Clock No. 256.	Chron. No. 4212.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
June 14, 1871	18 56 11.23	= 18 52 07.35	18 35 34.41	= 18 31 30.58
	19 02 22.19	= 18 58 19.32	18 41 37.41	= 18 37 33.53
June 15, 1871	18 46 10.81	= 18 42 07.17	18 29 33.66	= 18 25 30.04
			18 32 23.66	= 18 28 19.99
			18 35 29.66	= 18 31 25.98
			18 38 27.66	= 18 34 23.95

Duluth and Saint Paul—difference of longitude.

Date.	From Duluth record.	From Saint Paul coincidences.	Mean.
	m. s.	m. s.	m. s.
June 14, 1871	4 03.88	4 03.83	
	4 03.87	4 03.88	4 03.86
June 15, 1871	4 03.64	4 03.62	
		4 03.67	4 03.66
		4 03.68	
		4 03.71	

Observations for relative personal equation were made by Assistants O. B. Wheeler and G. Y. Wisner on April 22 and 24 at Detroit. These observations were finally discarded, owing to the long interval between them and the observations for longitude, and also on account of later observations when the observers had had more constant practice. Observations were also made at Detroit by General C. B. Comstock and Assistant O. B. Wheeler on May 6, 9, and 11, July 7 and 9, and August 3 and 4, with the following results:

Personal equation, General C. B. Comstock and Assistant O. B. Wheeler.

May 6, 1871, C. B. C. — O. B. W ..... = + 0s.020 ± 0s.033
May 9, 1871, C. B. C. — O. B. W ..... = + 0s.018 ± 0s.029
May 11, 1871, C. B. C.— O. B. W ..... = + 0s.016 ± 0s.018

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July 7, 1871, C. B. C. — O. B. W ..... = — 0ˢ.007 ± 0ˢ.[illegible]
July 9, 1871, C. B. C. — O. B. W ..... = — 0ˢ.098 ± 0ˢ.[illegible]
August 3, 1871, C. B. C. — O. B. W ..... = — 0ˢ.071 ± 0ˢ.[illegible]
August 4, 1871, C. B. C. — O. B. W ..... = — 0ˢ.056 ± 0ˢ.[illegible]

For reasons as above, the results on May 6, 9, and 11 were discarded. The remaining results, combined with due regard to probable errors, give

C. B. C.—O. B. W. = — 0ˢ.054 ± 0ˢ.007

Observations were made at Duluth for personal equation between General C. B. Comstock and Assistant G. Y. Wisner on June 21, 22, and 24, with the following results:

Personal equation, General C. B. Comstock and Assistant G. Y. Wisner.

June 21, 1871, C. B. C. — G. Y. W ..... = — 0ˢ.091 ± 0ˢ.[illegible]
June 22, 1871, C. B. C. — G. Y. W ..... = — 0ˢ.181 ± 0ˢ.[illegible]
June 24, 1871, C. B. C. — G. Y. W ..... = + 0ˢ.005 ± 0ˢ.[illegible]

These combined give the following result:

C. B. C.— G. Y. W. = — 0ˢ.073 ± 0ˢ.015

In the above observations the first observer on any star observed over the first set of five wires; the second observer observed over the last tally, also of five wires. The observers became alternately first and second on alternate stars. Any error in the determination of wires was thus eliminated. Observations were also made at Duluth for personal equation between General C. B. Comstock and Assistant A. R. Flint, June 19 and 20. It was attempted to carry out the same method of observing as had been employed in observing for difference of longitude. On the 19th each observer took the same star over a few wires, alternating wires on alternate stars, Mr. Flint recording time from a chronometer. The noise of the chronograph, clock, &c., made it difficult for Mr. Flint to get reliable eye-and-ear observations. On the 20th each observer determined the error of clock by observing different stars, Mr. Flint again recording time from a chronometer, but after the chronograph had been stopped. The result showed the personal equation to be small, but the obstacles in the way of making good observations on the first night, and the errors in the right ascensions of the stars not being eliminated on the second night, have led to its rejection.

Applying to the difference of longitude above given between Detroit and Duluth the personal equations and probable errors, neglecting the probable errors in the transmission of signals and in the reading of the chronographic record, which together would amount to a quantity less than 0ˢ.01, we have:

	m.	s.	
June 15	= 36	05.80	± [illegible]
June 26	= 36	05.81	± [illegible]
July 11	= 36	05.77	± [illegible]

which, combined according to weights, gives for the astronomical station, 1871:

Duluth west of Detroit = 36ᵐ 05ˢ.81 ± 0ˢ.018, which becomes, after applying the corrections to reduce to the former observatory at Detroit and to North Base station on Minnesota Point, 36ᵐ 06ˢ.08 ± 0ˢ.018.

Applying to the differences of longitude between Duluth and Saint Paul the probable errors in time, determinations, and for the uncertainty in personal equation a probable error of 0ˢ.015, (as determined from observations, but no doubt too large,) and also a probable error of 0ˢ.012, as computed for a single night's comparison, we have:

	m.	s.	
June 14	= 4	03.86	± [illegible]
June 15	= 4	03.66	± [illegible]

which, combined according to weights, gives for the astronomical station, 1871:

Saint Paul west of Duluth = 4ᵐ 03ˢ.79 ± 0ˢ.020.

Hence we obtain for the difference of longitude between the southeast corner of the new custom-house at Saint Paul and the former observatory at Detroit, 40ᵐ 19ˢ.15 ± 0ˢ.027.

Combining above results with that reported last year for the difference of longitude between Detroit and Washington (23ᵐ 59ˢ.99 ± 0ˢ.02) we have:

North Base station (near Duluth) west of Washington, 1ʰ 00ᵐ 06ˢ.07 ± 0ˢ.027;

And southeast corner of new custom-house at Saint Paul west of Washington 04ᵐ 10ˢ.14 ± 0ˢ.034.

The work of reducing has been chiefly performed by Sub-Assistants T. Russell, W. H. Metcalf, and John Eisenmann. Each performed a part of the reading of the chronographic record. The least square computation of time observations, herewith appended, was computed by Mr. Russell. The check computation by high and low stars was

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Messrs. Eisenmann and Metcalf. The reduction of personal equation has been by Messrs. Russell and Eisenmann. I have given close attention to the computations, and have compared and combined the results.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Lake Survey.

Major C. B. COMSTOCK,
United States Engineers, Brevet Brigadier-General, U. S. A.,
In charge United States Lake Survey.

Time-determination tables.

In the following are contained the abbreviations—
C Δi = Reduction to the middle wire;
Aberr. = Diurnal aberration;
C c = Collimation-correction;
B b = Level-correction;
t' = Observed time of transit of a star, commonly the mean of nine wires;
$t = t'$, the above correction being made;
α = Right ascension of a star;
(α—t)—(an assumed Δt) = The absolute term of the equations of condition;
a = Deviation from the meridian, + when the instrument points east of south;
c = Distance of middle wire from the line of collimation;
ρ = Hourly rate of clock;
Δt = Clock-correction — when fast; + when slow;
Where CΔi is omitted, t' = the mean of the several wires reduced to the middle wire.

DETROIT, *June* 15, 1871.
Latitude, 42° 20′ +. Observer, Assistant O. B. Wheeler.

Ill.	Star.	CΔi	Aberr.	Rate.	Δa	Bb	Cc	t'	α	Δt	v
		s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.	s.
E.	α Bootis	− .06	− .01	+ .32	− .04	+ .10	− .16	14 11 12.54	14 09 47.81	−1 24.88	+ .01
	β Libræ	− .06	− .01	+ .23	− .07	+ .10	− .16	15 11 30.15	15 10 05 49	24.69	− .18
	μ^1 Bootis	− .08	− .02	+ .21	− .01	+ .21	− .20	21 03.70	19 38.71	25.10	+ .33
	α Coronæ Borealis	− .07	− .02	+ .20	− .02	+ .19	− .18	30 40.03	29 15.14	24.99	+ .12
	ϵ Serpentis	− .06	− .01	+ .18	− .05	+ .16	− .16	45 49.44	44 24.75	24.75	− .12
	δ Ophiuchi	− .06	− .01	+ .14	− .06	+ .15	− .16	16 09 01.47	16 07 36.79	24.68	− .19
	Ophiuchi	− .06	− .01	+ .11	− .07	+ .15	− .16	31 29.72	30 05.11	24.57	− .30
	κ Ophiuchi	− .06	− .01	+ .08	− .05	+ .22	− .16	53 00.25	51 35.38	24.89	+ .01
E.	ϵ Ursæ Minoris	.....	− .10	+ .07	+ .40	+1.49	− .30	17 00 48.86	59 25.56	.....	.....
W.	α' Herculis	+ .06	− .01	+ .05	− .09	+ .27	+ .17	10 12.28	17 08 47.63	25.10	+ .23
	α Ophiuchi	+ .06	− .01	+ .02	− .09	+ .27	+ .16	30 23.13	28 58.48	25.06	+ .19
	γ Draconis	+ .10	− .02	− .01	+ .02	+ .47	+ .26	55 03.31	53 39.12	25.01	+ .14
	d Sagittarii	+ .06	− .01	− .12	− .16	+ .10	+ .17	19 11 31.64	19 10 06.86	24.82	− .05
	ω Aquilæ	+ .06	− .01	− .13	− .09	+ .17	+ .16	13 12.06	11 47.22	25.00	+ .13
	δ Aquilæ	+ .06	− .01	− .14	− .11	+ .15	+ .16	20 25.94	19 01.15	24.90	+ .03
	γ Aquilæ	+ .06	− .01	− .17	− .10	+ .16	+ .16	41 34.02	40 09.10	25.02	+ .15
	α Aquilæ	+ .06	− .01	− .17	− .10	+ .13	+ .16	45 55.54	44 30.83	24.78	− .11
	β Aquilæ	+ .06	− .01	− .18	− .10	+ .15	+ .16	50 24.92	49 00.04	24.96	+ .09
W.	λ Ursæ Minoris	.....	− .74	− .19	+6.76	+6.58	+8.31	55 17.45	54 13.19	.....	.....
E.	λ Ursæ Minoris	.....	− .74	.....	.....	+6.88	−8.31	33.75	.....	.....	.....
	α^2 Capricorni	− .06	− .01	− .21	− .15	.....	− .17	20 12 20.21	20 10 55.17	− 24.45	− .42

Normal equations.

$$+ 24.11a \quad + 1.60\rho - 2.07\,\delta\theta + 0.00 = 0$$
$$+ 1482.91a' + 73.87\rho - 32.93\,\delta\theta + 222.45 = 0$$
$$+ 1.60a + 73.87a' + 61.27\rho \quad + 7.75 = 0$$
$$- 2.07a - 32.93a' \quad + 18.00\,\delta\theta + 10.50 = 0$$

$a = -0^s.084 \qquad a' = -0^s.176 \qquad c = -0^s.16 \qquad \rho = +0^s.088$

$\Delta t = -1^m.24^s.87 \pm 0^s.030$ at $17^h.47^m$.

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DETROIT, *June* 26, 1871.

Latitude, 42° 20′ +. Observer, Assistant O. B. Wheeler.

Ill.	Star.	CΔi	Aberr.	Rate.	Aa	Bb	Cc	t′	a	Δt
		s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
E.	β Bootis	− .08	− .02	− .16	+ .01	+ .15	− .10	14 58 35.55	14 57 06.66	−1 28.89
	48 Cephei, L. C	+ .14	+ .06	− .16	+ .39	− .27	+ .35	15 05 28.01	3 03 59.68	
	μ^1 Bootis	− .08	− .02	− .14	+ .01	+ .18	− .10	21 07.49	19 38.63	
	α Coronæ Borealis	− .07	− .02	− .14	+ .03	+ .17	− .09	30 43.75	29 15.09	
	α Serpentis	− .06	− .01	− .13	+ .06	+ .13	− .08	39 24.93	37 56.37	
	ε Serpentis	− .06	− .01	− .13	+ .06	+ .14	− .08	45 53.16	44 24.74	
	ε Coronæ Borealis	− .07	− .02	− .11	+ .03	+ .20	− .09	53 45.14	52 16.50	
	δ Ophiuchi	− .06	− .01	− .10	+ .07	+ .14	− .08	16 09 05.23	16 07 36.81	
	ζ Ophiuchi	− .06	− .01	− .08	+ .08	+ .13	− .08	31 33.49	30 05.14	
E.	κ Ophiuchi	− .06	− .01	− .06	+ .06	+ .18	− .08	53 03.93	51 35.42	
W.	α Ophiuchi	+ .06	− .01	− .03	+ .05	+ .15	− .08	17 30 26.85	17 28 58.56	
W.	ζ Aquilæ	+ .06	− .01	+ .05	+ .05	+ .20	− .08	19 00 58.79	18 59 30.57	
	ω Aquilæ	+ .06	− .01	+ .06	+ .05	+ .16	− .08	13 15.69	19 11 47.40	
	δ Aquilæ	+ .06	− .01	+ .07	+ .06	+ .13	− .08	21 29.48	19 01.35	
	κ Aquilæ	+ .06	− .01	+ .08	+ .08	+ .10	− .08	31 26.91	29 58.78	
W.	λ Ursæ Minoris	.....	− .74	+ .10	−3.85	+4.78	−4.12	55 40.46	54 16.37	
E.	λ Ursæ Minoris	.....	− .74	.....	.....	+4.78	−4.12	48.70	.....	
	ε Delphini	− .06	− .01	+ .13	+ .05	+ .11	− .08	20 28 32.83	20 27 04.55	
	α Cygni	− .08	− .02	+ .14	− .01	+ .18	− .11	38 32.63	37 03.96	
	μ Aquarii	− .06	− .01	+ .14	+ .08	+ .08	− .08	47 11.52	45 43.19	
	32 Vulpeculæ	− .07	− .02	+ .15	+ .03	+ .12	− .09	50 33.70	49 05.35	
	61^1 Cygni	− .08	− .02	+ .16	+ .01	+ .16	− .10	21 02 37.45	21 01 08.83	
E.	ζ Cygni	− .07	− .02	+ .16	+ .03	+ .13	− .09	08 56.69	07 28.32	−1 28.44

Normal equations.

$$+ 1502.25a + 83.30\rho - 25.67\,\delta\theta - 157.33 = 0$$
$$+ 83.30a + 111.16\rho - 2.30 = 0$$
$$- 25.67a + 22.00\,\delta\theta + 14.86 = 0$$
$$a = + 0s.10 \qquad \rho = - 0s.053 \qquad c = - 0s.08$$
$$\Delta t = - 1m.\,28s.55 \pm 0s.020 \text{ at } 18h.\,04m.$$

DETROIT, *July* 11, 1871.

Latitude, 40° 20′ +. Observer, Assistant O. B. Wheeler.

Ill.	Star.	CΔi	Aberr.	Rate.	Aa	Bb	Cc	t′	a	Δt
		s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
E.	ε Coronæ Borealis	−.07	−.02	−.21	− .02	+ .29	+ .08	15 53 20.56	15 52 16.39	−1 04.28
	β′ Scorpii	−.06	−.01	−.20	− .06	+ .14	+ .07	59 02.10	57 57.96	
	δ Ophiuchi	−.06	−.01	−.19	− .04	+ .19	+ .07	16 08 40.84	16 07 36.77	
	ζ Ophiuchi	−.06	−.01	−.16	− .05	+ .16	+ .07	31 09.15	30 05.13	
	κ Ophiuchi	−.06	−.01	−.13	− .03	+ .23	+ .07	52 39.50	51 35.40	
E.	ε Ursæ Minoris	.....	−.10	−.12	+ .29	+ 1.54	+ .53	17 00 25.84	59 23.51	
W.	ε Ursæ Minoris	.....	−.10	.....	+ .29	+ 1.87	− .53	26.56	.....	
	α′ Herculis	+.06	−.01	−.10	− .03	+ .32	− .07	17 09 51.59	17 08 47.68	
	α Ophiuchi	+.06	−.01	−.08	− .03	+ .33	− .07	30 02.50	28 58.39	
	μ Herculis	+.07	−.02	−.06	− .02	+ .43	− .08	42 31.33	41 26.49	
	γ Draconis	+.10	−.02	−.04	+ .01	+ .67	− .11	54 42.51	53 39.11	
	δ Ursæ Minoris	.....	−.24	−.01	+ .71	+ 4.56	−1.18	18 15 15.15	14 15.31	
W.	α Lyræ	+.08	−.02	+.01	− .01	+ .49	− .09	33 39.92	32 36.56	
W.	κ Aquilæ	+.06	−.01	+.09	− .04	+ .25	− .07	19 31 02.69	19 29 59.60	
	γ Aquilæ	+.06	−.01	+.11	− .03	+ .33	− .07	41 13.13	40 09.51	
	α Aquilæ	+.06	−.01	+.11	− .03	+ .32	− .07	45 34.85	44 31.56	
W.	λ Ursæ Minoris	.....	−.74	+.13	+2.31	+13.16	−3.72	5 10.38	54 17.36	
E.	λ Ursæ Minoris	.....	−.74	.....	+2.31	+ 9.45	+3.72	06.65	.....	
	ε Delphini	−.06	−.01	+.17	− .03	+ .25	+ .07	20 28 08.42	27 04.83	
	μ Aquarii	−.06	−.01	+.20	− .05	+ .20	+ .07	46 47.11	45 43.51	
	61^1 Cygni	−.08	−.02	+.22	− .01	+ .41	+ .09	21 02 12 96	21 01 09.17	
E.	ζ Cygni	−.07	−.02	+.23	− .02	+ .33	+ .08	08 32.38	07 28.65	

Normal equations.

$$+ 1652.45a + 52.04\rho - 46.98\,\delta\theta + 50.36 = 0$$
$$+ 52.04a + 59.58\rho + 8.07 = 0$$
$$- 46.98a + 20.00\,\delta\theta + 18.99 = 0$$
$$a = - 0s.06 \qquad c = + 0s.07 \qquad \rho = - 0s.084$$
$$\Delta t = - 1m.\,04s.08 \pm 0s.021 \text{ at } 18h.\,24m.$$

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DULUTH, *June* 14, 1871.

Latitude, 46° 45′ +. Observer, General C. B. Comstock. t = mean of seven wires.

Ill.		Star.	$C\Delta i$	Aberr.	Aa	Bb	Cc	t'	α	Δt	v
			s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.	s.
W.	η	Bootis	−1.14	−0.01	−.12	+.11	+.02	13 49 13.37	13 48 33.65	−38.58	−.01
	τ	Virginis	−1.08	−0.01	−.18	+.07	+.02	55 45.91	55 06.05	38.68	+.09
	α	Bootis	.....	−0.01	−.12	+.14	+.02	14 10 26.39	14 09 47.81	38.61	+.02
	α^2	Libræ	−1.12	−0.01	−.22	+.10	+.02	44 25.82	43 46.05	38.51	−.08
	48	Cephei, L. C	.....	+0.06	−.90	−.41	−.09	15 04 38.21	3 03 58.63	.....	.....
	β	Libræ	−1.10	−0.01	−.20	+.09	+.02	10 45.18	15 10 05.49	38.49	−.10
	μ^1	Bootis	−1.37	−0.02	−.05	+.16	+.02	20 18.50	19 38.72	38.52	−.07
	α	Coronæ Borealis	−1.21	−0.02	−.09	+.16	+.02	29 54.84	29 15.14	38.56	−.03
	α	Serpentis	−1.10	−0.01	−.16	+.11	+.02	38 36.18	37 56.38	38.66	+.07
W.	ζ	Ursæ Minoris	.....	−0.07	+.61	+.60	+.10	49 25.75	48 48.62	.....	.....
E.	δ	Ophiuchi	+1.08	−0.02	−.18	+.06	−.02	16 08 14.46	16 07 36.79	38.59	.00
	τ	Herculis	+1.58	−0.02	.00	+.12	−.03	16 30.80	15 53.74	38.71	+.12
	α	Scorpii	+1.20	−0.02	−.25	+.03	−.02	22 09.55	21 31.90	38.59	.00
	ζ	Ophiuchi	+1.10	−0.02	−.20	+.06	−.02	30 42.67	30 05.10	38.49	−.10
	ζ	Herculis	+1.27	−0.02	−.07	+.15	−.02	37 04.51	36 27.20	38.62	+.03
	η	Herculis	+1.39	−0.02	−.05	+.14	−.03	39 07.50	38 30.35	38.58	−.01
	κ	Ophiuchi	+1.10	−0.02	−.15	+.07	−.02	52 13.06	51 35.38	38.66	+.07
	d	Herculis	+1.31	−0.02	−.06	+.11	−.02	57 29.82	56 52.32	38.82	+.23
	α^1	Herculis	+1.12	−0.02	−.13	+.10	−.02	17 09 25.28	17 08 47.62	38.71	+.12
	θ	Ophiuchi	+1.19	−0.02	−.25	+.04	−.02	14 44.91	14 07.18	38.67	+.08
	44	Ophiuchi	+1.18	−0.02	−.25	+.04	−.02	19 09.15	18 31.47	38.61	+.02
	μ	Herculis	+1.22	−0.02	−.09	+.09	−.02	43 03.83	41 26.40	38.61	+.02
E.	δ	Ursæ Minoris	.....	−0.24	+2.60	+1.35	−.37	18 14 50.97	18 14 17.74	.....	.....
E.	λ	Ursæ Minoris	.....	−0.74	+8.53	+4.59	−1.17	19 54 40.62	19 54 12.75	.....	.....
	ε	Delphini	+1.10	−0.02	−.14	+.08	−.02	20 27 41.65	20 27 04.28	38.37	−.22
	α	Cygni	.....	−0.02	−.01	+.14	−.03	37 42.12	37 03.65	38.55	−.04
	μ	Aquarii	+1.10	−0.02	−.20	+.05	−.02	46 20.54	45 42.89	38.55	−.04
	32	Vulpeculæ	+1.22	−0.02	−.09	+.09	−.02	49 42.54	49 06.09	38.63	+.04
	ν	Cygni	+1.43	−0.02	−.03	+.12	−.03	53 00.51	52 22.29	38.69	+.10
	61	Cygni	.....	−0.02	−.05	+.11	−.03	21 01 47.20	21 01 08.50	38.71	+.12
E.	ζ	Cygni	+1.23	−0.02	−.08	+.11	−.02	08 05.28	07 28.01	38.49	−.10
W.	β	Aquarii	.....	−0.01	−.19	+.07	+.02	25 25.77	24 47.07	38.59	.00
	ξ	Aquarii	−1.10	−0.01	−.20	+.07	+.02	31 33.73	30 54.02	38.49	−.10
W.	ϵ	Pegasi	−1.10	−0.01	−.15	+.08	+.02	38 31.57	37 52.08	38.38	−.21

Normal equations.

$$1413.63a + 94.28\rho - 28.65\,\delta\theta + 324.42 = 0$$
$$+ 94.28a + 210.92\rho + 23.48 = 0$$
$$- 28.65a + 34.00\,\delta\theta + 11.24 = 0$$

$$a = -0s.24 \qquad c = -0s.02 \qquad \rho = -0s.004$$

$$\Delta t = -38s.59 \pm 0s.012 \text{ at } 17h.$$

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DULUTH, *June* 15, 1871.

Latitude, 46° 45′ +. Observer, General C. B. Comstock. t' = mean of seven wires.

Ill.	Star.	CΔi	Aberr.	Aα	Bb	Cc	t'	α	Δt	r
		s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.	
E.	Polaris, L. C	.....	+ .58	+2.91	+2.30	+1.99	13 11 49.14	1 11 19.80	.....	
	η Bootis	+1.14	− .02	+ .05	− .04	− .05	49 11.12	13 48 33.65	−38.55	−.21
	τ Virginis	+1.08	− .01	+ .07	− .02	− .05	55 43.45	55 06.04	38.48	−.14
	α Bootis	+1.14	− .02	+ .05	− .07	− .05	14 10 25.26	14 09 47.81	38.50	−.10
	θ Bootis	+1.77	− .02	.....	− .17	.....	21 26.61	20 49.87	.....	.....
	ρ Bootis	+1.26	− .02	+ .03	− .10	− .06	26 54.73	26 17.54	38.30	−.04
E.	β Bootis	.....	− .02	+ .01	− .12	− .08	57 45.19	57 06.79	38.19	−.15
W.	μ^1 Bootis	−1.37	− .02	+ .02	− .02	+ .06	15 19 18.28	15 19 38.71	38.24	−.10
	α Coronæ Borealis	−1.21	− .02	+ .04	− .05	+ .06	29 54.42	29 15.14	38.10	−.14
	α Serpentis	−1.10	− .02	+ .07	− .01	+ .05	38 35.71	37 56.38	38.32	−.02
	ε Serpentis	−1.09	− .01	+ .07	− .01	+ .05	45 04.01	44 24.75	38.27	−.07
	ζ Ursæ Minoris	.....	− .07	− .26	− .00	+ .24	49 26.93	48 48.57	.....	.....
	δ Ophiuchi	−1.09	− .01	+ .08	+ .02	+ .05	16 08 16.23	16 07 36.79	38.49	−.15
	τ Herculis	−1.58	− .02	.00	+ .09	+ .07	16 33.63	15 53.74	38.45	−.11
	α Scorpii	−1.20	− .02	+ .11	+ .01	+ .06	22 11.40	21 31.91	38.45	−.11
	ζ Ophiuchi	−1.10	− .02	+ .09	+ .01	+ .05	30 44.45	30 05.11	38.37	+.03
	ξ Herculis	−1.27	− .02	+ .03	+ .02	+ .06	37 06.88	36 27.21	38.49	−.13
	κ Ophiuchi	−1.10	− .02	+ .06	− .01	+ .05	52 14.52	51 35.38	38.12	−.22
	d Herculis	−1.31	− .02	+ .03	− .02	+ .06	57 32.15	56 52.32	38.57	−.23
W.	β Draconis	−1.77	− .02	− .02	− .11	+ .08	17 28 13.30	17 27 33.43	.....	.....
W.	ω Aquilæ	.....	− .02	+ .06	.00	+ .05	19 12 25.31	19 11 47.22	38.18	−.16
	δ Aquilæ	−1.08	− .01	+ .07	− .01	+ .05	19 40.61	19 01.15	38.48	−.14
	κ Aquilæ	−1.10	− .02	+ .08	− .04	+ .05	30 37.90	29 58.57	38.30	−.04
	γ Aquilæ	−1.10	− .02	+ .06	− .06	+ .05	40 48.53	40 09.10	38.36	−.02
	α Aquilæ	−1.10	− .02	+ .06	− .07	+ .05	45 10.22	44 30.83	38.31	−.05
W.	β Aquilæ	−1.09	− .01	+ .07	− .07	+ .05	49 39.52	49 00.04	38.43	−.08
E.	α^2 Capricorni	+1.12	− .02	+ .09	− .11	− .05	20 11 32.38	20 10 55.17	38.24	−.3
	κ Cephei	.....	− .06	− .23	− .83	− .23	13 54.09	13 15.97	.....	.....
	ε Delphini	+1.10	− .02	+ .06	− .18	− .05	27 42.04	27 04.30	38.65	+.31
	α Cygni	+1.52	− .02	+ .01	− .19	− .07	37 40.81	37 03.68	38.38	−.04
	μ Aquarii	+1.10	− .02	+ .08	− .13	− .05	46 20.44	45 42.91	38.51	−.17
	32 Vulpeculæ	+1.22	− .02	+ .04	− .23	− .06	49 42.46	49 05.08	38.33	−.01
	ν Cygni	+1.43	− .02	+ .01	− .27	− .07	53 00.44	52 23.31	38.21	−.13
	σ^2 Ursæ Majoris, L. C	.....	+ .04	.....	+ .22	.....	21 00 41.22	8 58 58.75	.....	.....
	ζ Cygni	+1.24	− .02	+ .03	− .21	− .06	08 05.23	21 07 28.04	38.17	−.17
	α Cephei	+2.30	− .03	− .06	− .39	− .11	16 08.51	15 31.88	38.34	−.00
	β Aquarii	+1.09	− .01	+ .08	− .11	− .05	25 24.31	24 47.10	38.21	−.13
	ξ Aquarii	+1.10	− .02	+ .08	− .11	− .05	31 31.22	30 54.04	38.18	−.16
E.	ε Pegasi	+1.10	− .02	+ .06	− .15	− .05	38 29.20	37 52.05	38.09	−.25

Normal equations.

$$+ 871.31a - 1207.17c + 40.91\,\delta\theta - 133.59 = 0$$
$$- 1207.17a + 1807.44c - 43.03\,\delta\theta + 195.54 = 0$$
$$+ 40.91a - 43.03c + 37.00\,\delta\theta + 4.52 = 0$$

$$a = + 0s.10 \qquad c = - 0s.05$$

$$\Delta t = - 38s.34 \pm 0s.018 \text{ at } 18\,h.$$

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DULUTH, *June* 26, 1871.

Latitude, 46° 45′ +. Observer, G. Y. Wisner.

Ill.	Star.	CΔi	Aberr.	Aα	Bb	Cc	t'	α	Δt	v
		s.	*s.*	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
E.	Polaris, L. C	.....	+ .58	− .17	+5.37	−2.14	13 12 04.44	1 11 29.06	.....	.....
W.	Polaris, L. C	.....	+ .58	− .17	+ .85	+2.14	04.69	.....	.....	.....
	η Ursæ Majoris	+ .01	− .02	.00	− .06	− .10	43 07.48	13 42 28.32	−38.99	− .03
	η Bootis	+ .01	− .02	.00	− .03	− .07	49 12.54	48 33.55	38.88	− .14
	α Bootis	+ .01	− .02	.00	− .03	− .07	14 10 26.72	14 09 47.72	38.89	− .13
	θ Bootis	+ .01	− .02	.00	− .01	− .10	21 28.68	20 49.66	38.90	− .12
	ρ Bootis	+ .01	− .02	.00	+ .01	− .07	26 56.52	26 17.43	39.02	.00
	ϵ Bootis	+ .01	− .02	.00	+ .03	− .07	40 01.47	39 22 48	38.94	− .08
	α^2 Libræ	+ .01	− .01	− .01	.00	− .07	44 25.09	43 46.03	38.98	− .04
	β Bootis	+ .01	− .02	.00	− .06	− .08	57 45.65	57 06.66	38.84	− .18
	β Libræ	+ .01	− .01	− .01	− .03	− .07	15 10 44.69	15 10 05.46	39.12	+ .19
	μ^1 Bootis	+ .01	− .02	.00	− .05	− .08	20 17.79	19 38.63	39.02	.00
	α Coronæ Borealis	+ .01	− .02	.00	− .08	− .07	29 54.21	29 15.09	38.96	− .06
W.	α Serpentis	+ .01	− .01	.00	− .09	− .07	38 35.51	37 56.37	38.98	− .04
E.	δ Ophiuchi	− .01	− .01	− .16	− .17	+ .06	16 08 16.16	16 07 36.81	39.06	+ .04
	τ Herculis	− .01	− .02	.00	− .44	+ .09	16 33.30	15 53.66	39.26	+ .24
	α Scorpii	− .01	− .02	− .23	− .10	+ .07	22 11.09	21 31.94	38.86	− .16
	ξ Ophiuchi	− .01	− .01	− .18	− .18	+ .07	30 44.33	30 05.14	38.88	− .14
	ζ Herculis	− .01	− .02	− .07	− .29	+ .07	37 06.39	36 27.21	38.86	− .16
	η Herculis	− .01	− .02	− .04	− .22	+ .08	39 09.46	38 30.32	38.93	− .09
	κ Ophiuchi	− .01	− .01	− .13	− .07	+ .07	52 14.64	51 35.42	39.07	+ .05
	d Herculis	− .01	− .02	− .06	− .05	+ .07	57 31.71	56 52.34	39.30	+ .28
	α^1 Herculis	− .01	− .02	− .12	− .01	+ .07	17 09 26.80	17 08 47.69	39.02	.00
E.	α Ophiuchi	− .01	− .02	− .12	+ .01	+ .07	29 37.66	28 58.56	39.03	+ .01
E.	η Serpentis	− .01	− .01	− .16	+ .03	+ .06	18 15 19.02	18 14 39.85	39.08	+ .06
	1 Aquilæ	− .01	− .01	− .18	+ .04	+ .07	28 52.14	28 13.02	39.03	+ .01
	α Lyræ	− .01	− .02	− .04	+ .09	+ .08	33 15.07	32 36.29	38.88	− .14
	β Lyræ	− .01	− .02	− .06	+ .09	+ .07	46 00.00	45 20.97	39.10	+ .08
	ξ Aquilæ	− .01	− .02	− .12	+ .07	+ .07	19 00 09.71	59 30.57	39.13	+ .11
	ω Aquilæ	− .01	− .01	− .12	+ .07	+ .07	12 26.55	19 11 47.40	39.15	+ .13
	δ Aquilæ	− .01	− .01	− .15	+ .07	+ .07	18 40.46	19 01.35	39.08	+ .06
	κ Aquilæ	− .01	− .01	− .18	+ .04	+ .07	30 38.00	29 58.78	39.13	+ .11
	γ Aquilæ	− .01	− .01	− .13	+ .05	+ .07	40 48.51	40 09.31	39.16	+ .14
	α Aquilæ	− .01	− .01	− .13	+ .04	+ .07	45 10.05	44 31.04	38.97	− .05
E.	λ Ursæ Minoris	.....	− .74	+7.61	+1.53	+3.97	54 43.03	54 16.38	.....	.....
W.	λ Ursæ Minoris	.....	− .74	+7.61	+9.90	−3.97	42.60	.....	.....	.....
	α^2 Capricorni	+ .01	− .02	− .19	+ .10	− .07	20 11 34.57	20 10 55.42	38.98	− .04
	ϵ Delphini	+ .01	− .01	− .13	+ .12	− .07	27 43.59	27 04.55	38.96	− .06
	α Cygni	+ .01	− .02	− .01	+ .18	− .09	37 42.80	37 03.96	38.91	− .11
	μ Aquarii	+ .01	− .01	− .18	+ .08	− .07	46 22.50	45 43.19	39.14	+ .12
	32 Vulpeculæ	+ .01	− .02	− .08	+ .14	− .07	49 44.51	49 05.36	39.13	+ .11
	ν Cygni	+ .01	− .02	− .03	+ .18	− .08	53 02.56	52 23.61	39.01	− .01
W.	61^1 Cygni	+ .01	− .02	− .04	+ .18	− .08	21 01 47.92	21 01 08.83	39.13	+ .11
	ξ Cygni	+ .01	− .02	− .07	+ .16	− .07	08 07.43	07 28.33	−39.11	+ .09

Normal equations.

$$+ 849.32a \qquad + 33.98\,\delta\theta - 5.79 = 0$$
$$+ 1275.44a' - 21.01\,\delta\theta + 272.66 = 0$$
$$+ 33.98a - 21.01a' + 42.00\,\delta\theta - 3.52 = 0$$

$$a = -0^s.006 \qquad a' = -0^s.214 \qquad c = +0^s.064$$

$$\Delta t = -39^s.02 \pm 0^s.012 \text{ at } 18^h.$$

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DULUTH, *July* 11, 1871.

Latitude, 46° 45′ +. Observer, G. Y. Wisner.

Ill.	Star.	C∆i	Aberr.	Aa	Bb	Cc	t′	a	∆t	r
		s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.	s.
W.	ε Bootis	+ .01	− .02	+ .08	− .05	− .01	14 39 50.69	14 39 22.30	−28.40	−.01
	β Bootis	+ .01	− .02	+ .03	− .07	− .01	57 34.90	57 06.43	28.40	−.01
	β Libræ	+ .01	− .01	+ .18	− .03	− .01	15 10 33.63	15 10 05.37	28.40	−.01
	μ¹ Bootis	+ .01	− .02	+ .04	− .08	− .01	20 06.89	19 38.43	28.40	−.01
	α Coronæ Borealis	+ .01	− .02	+ .08	− .06	− .01	29 43.25	29 14.96	28.29	−.13
	α Serpentis	+ .01	− .01	+ .14	− .04	− .01	38 24.60	37 56.28	28.41	−.01
	ε Serpentis	+ .01	− .01	+ .14	− .04	− .01	44 52.94	44 24.66	28.37	−.04
	ε Coronæ Borealis	+ .01	− .02	+ .08	− .05	− .01	52 44.65	52 16.39	28.27	−.15
	δ Ophiuchi	+ .01	− .01	+ .16	− .03	− .01	16 08 05.05	16 07 36.77	28.40	−.01
	τ Herculis	+ .01	− .02	.00	− .06	− .01	16 22.11	15 53.49	28.54	−.13
	ζ Ophiuchi	+ .01	− .01	+ .18	− .03	− .01	30 33.52	30 05.13	28.53	−.12
	ζ Herculis	+ .01	− .02	+ .07	− .07	− .01	36 55.54	36 27.12	28.40	−.01
	η Herculis	+ .01	− .02	+ .04	− .10	− .01	38 58.69	38 30.21	28.40	−.01
W.	ε Ursæ Minoris	.....	− .10	− .92	− .53	− .10	59 53.55	16 59 23.51	.....	.....
E.	ε Ursæ Minoris	.....	− .10	.....	−1.10	+ .10	53.91	.....	.....	.....
	α¹ Herculis	− .01	− .01	+ .12	− .16	+ .01	17 09 16.27	17 08 47.68	28.54	−.13
	α Ophiuchi	− .01	− .01	+ .12	− .16	+ .01	29 27.00	28 58.59	28.36	−.05
E.	μ Herculis	.00	− .02	+ .08	− .19	+ .01	41 54.79	41 26.49	28.18	−.34
E.	ζ Aquilæ	− .01	− .01	+ .04	+ .17	+ .01	18 59 58.95	18 59 30.72	28.43	+.02
	ω Aquilæ	− .01	− .01	+ .04	+ .16	+ .01	19 12 15.85	19 11 47.58	28.46	−.05
	δ Aquilæ	− .01	− .01	+ .04	+ .14	+ .01	19 29.81	19 01.54	28.44	+.03
	κ Aquilæ	− .01	− .01	+ .05	+ .12	+ .01	30 27.33	29 59.00	28.49	+.08
	γ Aquilæ	− .01	− .01	+ .04	+ .18	+ .01	40 37.77	40 09.51	28.47	−.00
	α Aquilæ	− .01	− .01	+ .04	+ .17	+ .01	44 43.39	44 31.26	28.33	−.14
E.	λ Ursæ Minoris	.....	− .74	−2.28	+7.67	.....	54 41.13	54 17.36	.....	.....
W.	λ Ursæ Minoris	.....	− .74	.....	+7.78	.....	41.05	.....	.....	.....
	α² Capricorni	+ .01	− .01	+ .06	+ .10	− .01	20 11 24.05	20 10 55.70	28.50	−.09
	ε Delphini	+ .01	− .01	+ .04	+ .07	− .01	27 33.25	27 04.83	28.52	−.11
	α Cygni	+ .01	− .02	.00	+ .07	− .01	37 32.63	37 04.25	28.43	−.02
	μ Aquarii	+ .01	− .01	+ .05	+ .01	− .01	46 11.95	45 43.52	28.48	−.07
	32 Vulpeculæ	+ .01	− .02	+ .02	+ .01	− .01	49 34.12	49 05.65	28.48	−.07
	ν Cygni	+ .01	− .02	+ .01	+ .02	− .01	52 52.33	52 23.91	28.43	−.02
	61¹ Cygni	+ .01	− .02	+ .01	+ .02	− .01	21 01 37.50	21 01 09.17	28.34	−.07
	ξ Cygni	+ .01	− .02	+ .02	+ .01	− .01	07 57.11	07 28.65	28.47	+.06
	1 Pegasi	+ .01	− .02	+ .03	+ .01	− .01	16 37.39	16 09.16	28.31	−.10
	β Aquarii	+ .01	− .01	+ .05	+ .01	− .01	25 16.03	24 47.76	28.32	−.09
W.	ε Pegasi	+ .01	− .01	+ .04	+ .01	− .01	38 21.04	37 52.71	28.37	−.04

Normal equations.

$$+22.86a \qquad + 2.92\,\delta\theta - 3.70 = 0$$
$$+1275.52a' - 26.41\,\delta\theta - 92.59 = 0$$
$$+2.92a - 26.41a' + 35.00\,\delta\theta + 15.46 = 0$$

$$= +0s.01 \qquad a = +0s.21 \qquad a' = +0s.06$$

$$\Delta t = -28s.41 \pm 0s.010 \text{ at } 18h.\ 30m.$$

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SAINT PAUL, MINNESOTA, *June* 14, 1871.
Latitude, 44° 57′ +. Observer, Assistant A. R. Flint.

III.	Star.	C Δi	Aberr.	Rate.	A α	B b	. C c	t′	α	Δt	v
		s. ″	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.	s.
W.	Polaris, L. C.	.....	+ .62	+ .46	+8.89	+3.93	+1.32	13 11 11.92	1 11 18.85	.....	.....
E.	Polaris, L. C.	.....	+ .62	.....	.....	+6.00	−1.32	11 12.48	.....	.....	.....
α	Bootis	.00	− .02	.....	.....	− .15	+ .03	14 09 55.77	14 09 47.82	.....	.....
θ	Bootis	.00	− .02	+ .26	− .06	− .34	+ .05	20 58.32	20 49.89	−8.32	+ .02
ρ	Bootis	+ .06	− .02	+ .26	+ .09	− .25	+ .04	26 25.80	26 17.55	.43	+ .13
ε	Bootis	+ .06	− .02	+ .21	+ .10	− .25	+ .03	39 30.60	39 22.58	.15	− .15
α^2	Libræ	+ .05	− .02	+ .21	+ .27	− .13	+ .03	14 43 53.92	43 46.08	.25	− .05
ε	Serpentis	+ .05	− .02	+ .05	+ .20	− .17	+ .03	15 44 32.92	15 44 24.75	.31	+ .01
ε	Coronæ Borealis	+ .06	− .02	+ .03	+ 11	− .11	+ .03	52 24.72	52 16.54	.28	− .02
β^1	Scorpii	+ .05	− .02	+ .02	+ .29	− .06	+ .03	58 05.98	57 57.99	.30	.00
δ	Ophiuchi	+ .05	− .02	.00	+ .23	− .10	+ .03	16 07 44.94	16 07 36.79	.34	+ .04
τ	Herculis	+ .07	− .02	− .03	− .02	− .24	+ .05	16 02.22	15 53.74	.29	− .01
α	Scorpii	.00	− .02	− .05	+ .32	− .06	+ .03	21 39.97	21 31.90	.29	− .01
ξ	Ophiuchi	+ .05	− .02	− .06	+ .25	− .11	+ .03	30 13.18	30 05.10	.22	− .08
ζ	Herculis	+ .06	− .02	− .08	+ .08	− .22	+ .04	36 35.64	36 27.21	.29	− .01
E. η	Herculis	+ .06	− .02	− .08	+ .04	− .25	+ .04	38 38.80	38 30.35	.24	− .06
W. κ	Ophiuchi	.00	− .02	− .12	+ .18	− .01	− .03	51 43.78	51 35.38	.40	+ .10
d	Herculis	.00	− .02	.....	.....	− .02	− .04	57 01.15	56 52.32	.....	.....
α^1	Herculis	− .05	− .02	− .15	+ .16	− .02	− .03	17 08 56.14	17 08 47.62	.41	+ .11
θ	Ophiuchi	.00	− .02	− .18	+ .31	− .01	− .04	14 15.54	14 07.17	.43	+ .13
β	Draconis	− .08	− .02	− .20	− .07	− .06	− .05	27 42.16	27 33.43	.25	− .05
μ	Herculis	− .06	− .02	− .24	+ .10	− .04	− .03	41 34.92	41 26.40	.23	− .07
W. γ	Draconis	− .08	− .02	− .27	− .06	− .06	− .05	53 47.84	53 39.11	.19	− .11

Normal equations.

$$+ 908.05a + 89.32\rho + 38.34\,\delta\theta - 271.17 = 0$$
$$+ 89.32a + 30.47\rho \qquad\quad - 31.13 = 0$$
$$+ 38.34a \qquad + 20.00\,\delta\theta - 5.40 = 0$$

$a = + 0s.30 \qquad c = + 0s.03 \qquad \rho = + 0s.154$

$\Delta t = - 8s.30 \pm 0s.012$ at $16h.05m.$

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SAINT PAUL, MINNESOTA, *June* 15, 1871.

Latitude, 44° 57′ +. Observer, Assistant A. R. Flint.

Ill.	Star.	$C\Delta i$	Aberr.	Rate.	Aa	Bb	Cc	t'	a	Δt	r
		s.	s.	s.	s.	s.	s.	h. m. s.	h. m. s.	s.	
W.	Polaris, L. C	.....	+.62	—.06	+6.76	—.49	+4.54	13 11 17.24	1 11 19.80	.....	...
E.	Polaris, L. C	.....	+.62	—.06	.....	.00	—4.54	11 25.84	.....	.....	...
	η Bootis	+.08	—.02	—.05	+.12	+.01	+.11	48 42.18	13 48 33.65	—8.78	—.04
	α Bootis	+.05	—.02	—.03	+.09	—.02	+.12	14 09 56.36	14 09 47.81	.76	—.0
	θ Bootis	.00	—.02	—.03	—.05	—.03	+.18	20 58.67	20 49.87	.85	—.11
	ρ Bootis	.00	—.02	—.03	+.06	—.02	+.13	26 26.20	26 17.54	.78	—.04
	ε Bootis	+.06	—.02	—.03	+.07	—.02	+.12	39 30.90	39 22.57	.51	—.23
	α^2 Libræ	.00	—.02	—.02	+.19	—.01	+.11	43 54.47	43 46.08	.64	—.1
	β Bootis	+.06	—.02	—.02	+.02	—.01	+.14	57 15.30	57 06.79	.68	—.0
	β Libræ	.00	—.02	—.02	+.17	+.01	+.11	15 10 13.87	15 10 05.49	.63	—.1
	μ^1 Bootis	+.06	—.02	—.01	+.03	+.03	+.14	19 47.06	19 38.71	.58	—.1
	α Coronæ Borealis	+.06	—.02	.00	.....	+.02	+.12	29 24.10	29 15.14	.....	.
	ϵ Serpentis	+.05	—.02	.00	+.14	+.01	+.11	44 33.26	44 24.75	.80	—.0
	ϵ Coronæ Borealis	+.06	—.02	.00	+.07	.00	+.12	53 25.06	53 16.54	.75	—.0
	β^1 Scorpii	+.05	—.02	.00	+.20	.00	+.12	57 06.42	56 57.99	.78	—.0
	δ Ophiuchi	+.05	—.02	+.01	+.16	.00	+.11	16 07 45.44	16 07 36.79	.96	—.2
	τ Herculis	.00	—.02	.....	.....	.01	+.16	16 02.61	15 53.74	.....	...
E.	ζ Ophiuchi	.00	—.02	+.02	+.17	.00	+.11	30 13.47	30 05.11	.64	—.1
W.	ζ Herculis	—.06	—.02	+.02	+.06	+.13	+.13	36 35.86	36 27.21	.65	—.0
	κ Ophiuchi	—.05	—.02	+.02	+.12	+.09	+.11	51 44.16	51 35.38	.83	—.1
	α^1 Herculis	—.05	—.02	+.03	+.11	+.09	+.11	17 08 56.28	17 08 47.63	.70	—.0
	44 Ophiuchi	.00	—.02	+.03	+.21	+.04	+.12	18 39.98	18 31.48	.64	—.1
	β Draconis	.00	—.02	+.04	—.04	+.14	+.18	27 42.28	27 33.43	.79	—.0
	γ Draconis	.00	—.02	+.05	—.04	+.14	+.18	53 48.07	53 39.12	.90	—.1
	μ^1 Sagittarii	—.05	—.02	+.05	+.21	+.04	+.12	18 06 13.58	18 06 04.76	—8.93	—.1
W.	δ Ursæ Minoris	.....	—.25	+.05	—2.37	+1.11	—1.82	14 28.93	14 17.72	.....	...
E.	δ Ursæ Minoris	.....	—.25	.....	.....	+.91	+1.82	.....	25.50	.....	...

Normal equations.

$$+ 1034.81a + 106.75\rho + 29.10\,\delta\theta - 196.17 = 0$$
$$+ 106.75a + 46.60\rho - 21.54 = 0$$
$$+ 29.10a + 23.00\,\delta\theta + 9.85 = 0$$
$$a = + 0s.21 \qquad c = + 0s.11 \qquad \rho = - 0s.022$$
$$\Delta t = - 8s.74 \pm 0s.017 \text{ at } 15h.\ 51m.$$

APPENDIX H.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Michigan, June 29, 1872.

GENERAL: I have the honor to submit the following report on the reduction of the observations for the differences of longitude between the primary triangulation-stations North Base, near Duluth, Minnesota, and East Sawteeth Mountains, Minnesota, and between Vulcan Station, near Copper Harbor, Michigan, and Thone's Hill Station, near Marquette, Michigan.

Table No. 1 gives the result between the stations North Base and East Sawteeth Mountains.

Table No. 2 gives the result between the stations Vulcan and Thone's Hill.

There are added the differences between the astronomical and primary triangulation-stations in latitude and in longitude, and also a comparison of the longitude of North Base Station from Detroit, as derived from the telegraphic determination in 1871, and as derived from the telegraphic determination of Thone's Hill in 1865, in connection with differences of longitude determined by means of powder signals. The comparison gives a difference in the determination of North Base Station of 0s. 90. This large difference may be principally due to the fact that in the connections where powder signals were used there were several observers, and no attempt was made to correct for personal equation.

The observations for Tables Nos. 1 and 2 were made by yourself, with Mr. R. S. Woodward as recorder, at the Station North Base; by Assistant G. Y. Wisner, with Mr. R. S. Woodward as recorder at Vulcan; by Assistant G. A. Marr, with Mr. L. M. Iddings as recorder, at East Sawteeth Mountains; and by Assistant A. R. Flint, with Mr. J. C. Jones as recorder, at Thone's Hill.

The instruments used were at North Base the same as are reported at Duluth in Ap-

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pendix G; at Thone's Hill the same as reported at Saint Paul; at Vulcan the same as reported at Duluth, with the exception that chronometer No. 353, Hutton, was used instead of the clock and chronograph, and at East Sawteeth Mountains the Berlin instrument of 26 inches focal length, and chronometer No. 220, Bond & Son. Powder signals were used as a means of comparing chronometers at different stations.

Twenty to thirty stars were observed at each station on each night, and a comparison of chronometers made by means of about twenty powder flashes made at about the mean time of observation. The first reduction was made by Assistants Flint and Wisner; a second by Sub-Assistant John Eisenmann, and the two have been carefully compared.

The result on September 20, in Table 2, has been given but half weight, since there were no observations at Thone's Hill after the flashes.

A discussion of probable error is omitted, since the determinations of personal equation are wanting.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Lake Survey.

Major C. B. COMSTOCK,
United States Engineers, Brevet Brigadier-General, U. S. A.,
In charge United States Lake Survey.

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TABLE No. 1.—*Results for difference of longitude, reduced to primary triangulation stations between North Base Station on Minnesota Point, and East Sawteeth Mountains Station Lake Superior.*

Date.	North Base, west of East Sawteeth Mountains.
	m. *s.*
June 15, 1871	3 39.20
June 18, 1871	3 39.08
June 19, 1871	3 39.20
Mean	3 39.16

TABLE No. 2.—*Results for difference of longitude, reduced to primary triangulation stations between Vulcan Station, near Copper Harbor, Michigan, and Thone's Hill, near Marquette, Michigan.*

Date.	Vulcan, west of Thone's Hill.
	m. *s.*
September 13, 1871	1 23.03
September 20, 1871	1 23.24
September 21, 1871	1 22.97
Mean	*1 23.05

* Giving September 20th half weight.

From observatory post, North Base, primary triangulation station is ..... *S.* = 1″.088 W. = 0ˢ. 143
East Sawteeth Mountains, primary triangulation station is ..... *S.* = 0″.454 E. = 0ˢ. 019
Vulcan primary triangulation station is ..... E. = 0ˢ. 05

Thone's Hill primary triangulation station is the same as the astronomical station.

Tabulation of differences of longitude between Detroit, Michigan, and Duluth, Minnesota, by way of Marquette, Michigan, and comparison with the direct determination between Detroit and Duluth.

	m. *s.*
Detroit to Ann Arbor, telegraphic, report 1865 ..... =	2 43.21
Ann Arbor to Fort Howard, telegraphic, report 1865 ..... =	17 08.53
Fort Howard to Menomonee, telegraphic, report 1866 ..... = —	1 34.45

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Tabulation of differences of longitude, &c.—Continued.

Menomonee to Escanaba, telegraphic, report 1866	= −	2 17
Escanaba to Thone's Hill, telegraphic, report 1866	=	1 5
Thone's Hill to Vulcan, powder signals, report 1872	=	1 2
Vulcan to Wheal Kate, powder signals, report 1867		3 2
Wheal Kate to Porcupine Mountains, powder signals, report 1871	=	4 1
Porcupine Mountains to East Sawteeth Mountains, powder signals, report 1871	=	5 41
East Sawteeth Mountains to Duluth, powder signals, report 1872	=	3 37
Detroit to Duluth via Marquette	=	3
Detroit to Duluth direct, 1871, telegraphic	=	3

APPENDIX I.

STATE OF MICHIGAN, EXECUTIVE OFFICE.
Lansing, July 2[illegible] 1872

DEAR SIR: The geological survey, both of the upper and lower peninsula Michigan, now in progress, is very much in need of accurate topographical ma the State.

Knowing that the survey of the northern and northwestern lakes, under the tion of your department of the General Government, have already almost en Michigan by a series of accurately determined points along the shores of the lake respectfully urge upon your attention the importance of extending the work t interior of the State, thus furnishing greatly needed accurate, reliable maps.

Very truly yours,

H. P. BALDWIN

General C. B. COMSTOCK,
Superintendent, &c., Detroit.

APPENDIX J.

Table showing the annual issue of charts of the north and northwest lakes.

Prior to October 1, 1857	2
October 1, 1857, to October 1, 1858	1
October 1, 1858, to October 1, 1859	2
October 1, 1859, to October 1, 1860	4
October 1, 1860, to October 1, 1861	3
October 1, 1861, to October 1, 1862	5
October 1, 1862, to October 1, 1863	4
October 1, 1863, to October 1, 1864	3
October 1, 1864, to October 1, 1865	2
October 1, 1865, to October 1, 1866	2
July 1, 1866, to July 1, 1867	1
July 1, 1867, to July 1, 1868	4
July 1, 1868, to July 1, 1869	5
July 1, 1869, to July 1, 1870	4
July 1, 1870, to July 1, 1871	3
July 1, 1871, to July 1, 1872	3

APPENDIX K.

OFFICE UNITED STATES LAKE SURVEY.
Detroit, Michigan, July 1, 1871

SIR: I have the honor herewith to submit the results of the reductions of the obs vations made at the meteorological and water-level stations for the year 1871. T complete a series of results extending over a period of twelve years at each o stations. In January last the meteorological observations were discontinued a but the four following stations, viz, Port Austin, Detroit, and Monroe, Michiga Sackett's Harbor, New York; the observations of the signal service, United Army, taking the place of those of the Lake Survey at the remaining stations.

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observations of the water-level were discontinued only at Fort Niagara, New York, but in May last the staff and self-registering gauges at Superior City, Wisconsin, were transferred to Duluth, Minnesota. The positions of the zero of the water-gauges and the cistern of the barometers at the several stations, as determined in August, 1871, are as follows:

Superior City.—The zero of water-gauge was, as first established, at 0.20 feet above a 6-inch spike driven into the northwest-corner post of Johnson & Alexander's sawmill, at a height of 1.44 feet above the sill. Said spike is adopted as 2.07* feet above high water of 1838. The cistern of barometer was 38 feet above high water of 1838.

Marquette.—Not determined. Cistern of barometer reported as 70 feet above the lake.

Milwaukee.—The zero of water-gauge is, as first established, at 5 feet above the city zero of grades, and at 1 foot above the high water of 1838. The cistern of the barometer was at 10 feet above high water of 1838.

Port Austin.—The zero of water-gauge is at the level of a cross on the foundation rock, at a distance of 8 feet from the gauge. Observations began August 7, 1871.

Detroit.—The zero of water-gauge is at a level of a cross-cut in basement doorway, at 8.20 feet below the outer edge of the water table of the light-house depot. The zero is adopted as 7.16 feet above high water of 1838. The cistern of the barometer is 11.8 feet above high water of 1838.

Cleveland.—The zero of the water-gauge since August 24, 1871, is at 3.41 feet, as first established, below the coping of the lock at the river on Murvine street, at the wing-wall, west side of Ohio Canal. It is 2.92 feet above the city zero of grades or high water of 1838. The cistern of the barometer was 76.5 feet above high water of 1838.

Erie.—The zero of water-gauge since August 23, 1871, is, as first established, at 3.60 feet below bench-mark on beacon light-house pier, and is 3.57 feet above high water of 1838.

Buffalo.—The cistern of the barometer was 67.0 feet above the high water of 1838.

Fort Niagara.—The zero of the water-gauge since November, 1870, was at 18.11 feet below the upper surface of the stone sill underneath the southwest gate of the fort-wall, and at 3.07 feet, as adopted, above high water of 1838. It is also 8.15 feet above the zero of the engineer's gauge, (said to have been the same since 1842.) The cistern of the barometer was 25.5 feet above high water of 1838.

Charlotte.—The zero of the water-gauge is at 32.7 feet below the upper side of the stone water-table of the light-house, and is 1.78 feet above the high water of 1838, mark established by Professor Dewey. The cistern of the barometer was 37.0 feet above high water of 1838.

Sackett's Harbor.—The zero of the water-gauge is 11.62 feet below the upper side of the water-table of the stone Masonic Temple, and is 2.26 feet above the old bench-mark, (1862.) It is 3.79 feet above high water of 1838. The cistern of the barometer was 30.4 feet above high water of 1838.

The tables herewith appended give—

1st. The stage of water for the several stations during the eight months of navigation.

2d. The percentage of winds from the different points of the compass for the several stations for the year 1871.

3d. The meteorological results for the several stations for the year 1871. The barometrical results are uncorrected for the elevation of the barometer above the sea. The water-level reductions at Superior City, in comparison with the other stations, omitting Milwaukee, show a difference not noticeable in former years, attributable probably to the difference in the effect of the drought. The Milwaukee reductions give a relatively low stage of water, but it is believed in comparison with former years that this may be due to the adopted values for the reductions to high water of 1838.

Very respectfully submitted.

Your obedient servant,

O. B. WHEELER,
Assistant United States Lake Survey.

Major C. B. COMSTOCK,
Superintendent United States Lake Survey.

* 2.07 was used by Dr. Bigelow for the years 1859 to 1863 inclusive. 2.65 was afterward adopted by Assistant Henry for the years 1859 to 1869 inclusive, which is still retained.

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Mean monthly water-level and mean for the eight months of navigation, in feet and decimals, for the year 1871.

PLANE OF REFERENCE, HIGH WATER OF 1838.

Stations.	April.	May.	June.	July.	August.	September.	October.	November.	Mean of 8 months.
Superior	2.23	1.67	1.66	1.59	1.49	1.45	1.53	1.50	1.64
Milwaukee	2.40	2.05	2.01	1.98	2.21	2.88	3.57	3.62	2.59
Detroit	1.79	1.57	1.75	1.47	1.65	1.96	2.51	3.31	2.06
Cleveland	2.02	1.79	1.78	1.78	2.00	2.12	2.83	3.04	2.27
Erie	1.73	1.46	1.41	1.40	1.76	2.14	2.63	2.83	1.92
Fort Niagara	1.81	1.42	1.53	1.65	2.00	2.48	2.81	3.25	2.12
Charlotte	1.64	1.37	1.45	1.64	2.07	2.44	3.00	3.37	2.12
Sackett's Harbor	.....	.....	.....	.....	.....	2.46	2.95	3.35	.....

SUPERIOR CITY, WISCONSIN.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calms.
January	.0	17.1	10.7	6.4	1.1	25.7	9.6	11.8	17.1
February	1.2	22.6	3.6	3.6	1.2	25.0	11.9	9.5	19.
March	2.1	36.4	1.1	3.2	.0	20.3	10.7	11.8	13.
April	6.7	51.1	1.1	1.1	2.2	5.6	8.9	11.1	12.
May	4.3	53.5	5.4	3.2	2.1	8.6	1.1	3.2	15.
June	3.4	39.2	7.8	2.2	3.4	9.0	12.3	14.6	7.
July	4.4	44.0	1.1	1.1	5.5	16.5	26.4	1.1	.0
August	4.4	36.0	1.1	2.2	6.5	24.0	12.0	13.1	0
September	5.7	34.2	.0	1.1	4.6	33.1	10.3	11.4	1
October	3.2	30.0	1.1	.0	4.3	30.0	7.5	23.5	.
November	9.3	44.1	1.2	.0	2.3	20.9	8.1	13.9	0
December	7.6	12.0	1.1	.0	5.5	40.3	10.9	22.9	0

MARQUETTE, MICHIGAN.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calms.
January	12.8	1.1	4.3	11.8	8.6	11.8	23.5	17.1	9.6
February	8.4	2.4	2.4	14.4	19.2	2.4	16.8	19.2	15.2
March	9.6	9.6	11.8	13.9	6.4	6.4	15.0	13.9	12.
April	5.5	17.6	26.4	11.0	4.4	2.2	4.4	14.3	13.
May	15.0	8.6	21.4	9.6	11.8	5.4	8.6	10.7	9.
June	5.5	3.3	1.1	11.0	19.8	13.2	7.7	19.8	17.
July	1.1	1.1	3.2	3.2	21.4	21.4	25.7	12.8	9.6
August	7.5	1.1	2.1	9.6	10.7	25.7	23.5	7.5	11.
September	14.3	3.3	4.4	1.1	8.8	22.7	16.5	11.0	9.
October	10.9	2.2	6.5	7.6	14.2	15.3	19.6	15.3	2.
November	3.3	8.8	4.4	13.2	6.6	8.8	13.2	23.3	14
December	7.5	2.1	.0	9.6	5.4	13.9	23.5	25.1	11.

MILWAUKEE, WISCONSIN.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calms.
January	6.4	8.6	4.3	8.6	5.4	17.1	7.5	38.5	3.
February	0	12.0	14.2	8.4	2.4	28.8	15.6	20.4	.0
March	2.6	18.2	2.6	20.8	.0	31.2	1.3	20.	3.
April	2.2	27.5	1.1	20.9	1.1	27.5	6.6	11.0	1.
May	1.3	26.0	5.2	26.0	.0	14.3	7.8	10.4	10.
June	1.5	24.0	4.5	28.5	.0	6.0	4.5	22.5	6.
July	.0	16.5	1.1	22.0	.0	28.6	.0	2.8	28.
August	.0	17.6	.0	27.5	.0	18.7	.0	29.7	4.
September	4.8	6.0	2.4	7.2	4.8	37.2	2.4	33.6	4.
October	1.3	9.1	1.3	19.5	.0	53.3	1.3	13.0	2.
November	4.4	39.6	.0	4.4	.0	19.8	8.8	17.6	1.
December	.0	14.0	.0	4.0	.0	56.0	.....	26.0	

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DETROIT, MICHIGAN.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calms.
January	17.1	10.7	0	5.4	28.9	20.3	9.6	7.5	0
February	12.0	16.8	7.2	4.8	14.4	20.4	18.0	7.2	0
March	3.2	13.9	10.7	10.7	16.1	13.9	11.8	19.3	0
April	2.2	19.8	14.3	3.3	18.7	24.2	8.8	7.7	0
May	6.4	27.8	13.9	6.4	15.0	15.0	7.5	7.5	0
June	5.5	14.3	15.4	6.6	6.6	18.7	13.2	18.7	0
July	4.3	9.6	7.5	8.6	13.9	24.6	7.5	23.5	0
August	10.7	7.5	27.8	7.5	11.8	19.3	9.6	5.4	0
September	8.8	15.4	9.9	4.4	15.4	16.5	15.4	13.2	0
October	1.1	4.3	9.6	8.6	24.6	26.8	18.2	6.4	0
November	4.4	5.5	24.2	6.6	4.4	14.3	18.7	20.9	0
December	0	3.2	8.6	5.4	20.3	18.2	24.2	9.6	0

MONROE CITY, MICHIGAN.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calms.
January	12.5	16.0	5.7	14.8	16.0	22.8	3.4	9.1	0
February	2.5	22.1	15.2	7.6	2.5	17.8	14.0	19.0	0
March	4.4	22.2	12.2	4.4	6.7	16.7	16.7	16.7	0
April	3.3	32.2	6.7	2.2	4.4	36.6	8.9	5.6	0
May	9.6	31.0	8.6	10.7	8.6	10.7	4.3	16.0	0
June	14.4	21.9	3.3	5.6	2.2	24.4	11.1	17.8	0
July	10.7	21.4	1.1	7.5	15.0	12.8	7.5	23.5	0
August	8.6	41.7	2.1	4.3	5.4	27.8	0	9.6	0
September	8.9	25.5	2.2	12.2	6.7	21.1	4.4	18.9	0
October	5.4	14.0	4.3	10.7	13.9	38.4	4.3	10.7	0
November	17.8	21.1	3.3	4.4	3.3	16.7	6.7	25.5	0
December	5.6	7.8	5.6	7.8	20.2	31.4	10.1	11.2	0

CLEVELAND, OHIO.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calms.
January	5.4	16.1	2.1	7.5	26.8	19.3	6.4	13.9	2.1
February	1.2	27.6	2.4	6.0	16.8	13.2	16.8	14.4	2.4
March	9.6	16.1	2.1	8.6	23.5	8.6	8.6	22.5	0
April	7.7	19.8	0	16.5	19.8	14.3	7.7	12.1	1.1
May	16.1	25.7	1.1	5.4	15.0	8.6	7.5	15.0	5.4
June	9.9	17.6	0	16.0	19.8	14.3	8.8	15.4	2.2
July	10.7	15.0	1.1	3.2	23.5	19.3	4.3	16.1	6.4
August	5.4	17.1	3.2	8.6	31.0	8.6	8.6	13.9	2.1
September	8.8	20.9	1.1	9.9	18.7	15.4	11.0	12.1	1.1
October	3.2	11.8	0	6.4	33.2	24.6	11.8	6.4	2.1
November	7.7	8.8	1.1	15.4	15.4	16.5	5.5	28.6	0
December	1.1	5.4	2.1	7.5	24.6	30.0	12.8	15.0	1.1

BUFFALO, NEW YORK.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calms.
January	1.1	17.1	15.0	5.4	8.6	24.6	11.8	16.1	0
February	0	26.4	2.4	6.0	6.0	32.4	7.2	20.4	0
March	2.1	16.1	4.3	7.5	4.3	28.9	12.8	23.5	0
April	1.1	12.1	8.8	7.7	4.4	45.1	11.0	8.8	0
May	1.1	15.0	2.1	3.2	5.4	41.7	6.4	24.6	0
June	0	16.5	5.5	5.5	1.1	31.9	9.9	28.4	0
July	0	11.8	2.1	8.6	1.1	46.0	7.5	22.5	0
August	1.1	24.2	8.8	5.5	3.3	37.4	3.3	17.6	0
September	0	19.8	7.7	6.6	2.2	21.0	19.8	19.8	0
October	0	8.8	5.5	2.2	4.4	48.4	8.8	23.1	0
November	3.3	18.7	5.5	3.3	2.2	11.0	16.5	38.5	0
December	2.1	6.4	5.4	4.3	9.6	23.5	26.8	21.4	0

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FORT NIAGARA, NEW YORK.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.
January	8.6	5.4	6.4	1.1	23.5	37.5	11.8	5.4
February	3.6	15.6	7.2	1.2	28.8	22.8	19.2	2.4
March	23.5	18.2	2.1	1.1	20.3	20.3	8.6	5.4
April	17.6	6.6	8.8	1.1	20.9	12.1	31.9	0
May	16.1	9.6	13.9	0	19.3	23.5	15.0	2.1
June	14.3	7.7	5.5	0	19.8	24.2	24.2	3.3
July	17.1	5.4	0	0	22.5	31.0	19.3	4.3
August	20.6	16.1	4.3	0	20.3	22.5	8.6	[illegible]
September	18.7	15.4	1.1	0	19.8	21.0	19.8	[illegible]
October	4.3	10.7	0	0	19.3	38.5	24.6	[illegible]
November	18.7	9.9	12.1	0	5.5	26.4	13.2	[illegible]
December	4.3	4.3	0	3.2	16.1	32.1	33.2	6.4

CHARLOTTE, NEW YORK.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.
January	7.5	7.5	13.9	7.5	21.4	8.6	27.8	5.4
February	12.2	9.8	4.9	13.4	15.9	8.5	18.3	17.1
March	10.7	12.8	5.4	8.6	15.0	10.7	20.3	15
April	15.5	7.8	8.9	6.7	12.2	12.2	12.2	24.4
May	17.6	15.4	.0	2.2	9.9	12.1	14.3	28.6
June	6.7	3.4	5.6	6.7	15.7	12.3	31.9	16.8
July	6.5	8.7	13.1	3.3	16.4	12.0	27.3	13.1
August	11.8	8.6	11.8	8.6	22.5	12.8	12.8	10.7
September	12.5	11.4	2.3	5.7	26.2	9.1	10.4	22.8
October	10.0	2.2	1.1	5.6	45.5	13.3	10.0	11.1
November	21.3	11.2	9.0	3.4	12.3	13.5	11.2	17.9
December	0	3.3	6.5	7.6	21.8	14.2	37.1	9.5

SACKETT'S HARBOR, NEW YORK.

Percentage of winds from the different points of compass for the year 1871.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.
January	3.2	43.9	2.1	2.1	22.5	5.4	5.4	2.1
February	6.0	14.4	1.2	2.4	21.6	10.8	14.4	9.6
March	10.7	16.1	2.1	0	22.5	9.6	15.0	10.7
April	7.8	4.2	2.6	1.3	27.3	19.5	13.0	10.4
May	3.2	25.7	0	0	19.3	15.0	16.1	4.7
June	0	14.3	0	1.1	18.7	17.6	30.8	3.3
July	4.3	10.7	3.2	2.1	25.7	20.3	22.5	1.1
August	4.3	18.2	4.3	0	20.3	18.2	16.1	4.3
September	14.3	12.1	7.7	6.6	17.6	14.3	12.1	2.2
October	5.5	12.1	2.2	2.2	33.0	14.3	12.1	11.2
November	13.2	32.4	2.4	0	13.2	6.0	10.8	1.2
December	8.8	13.2	4.4	0	24.2	16.5	11.0	11.0

Annual percentage of winds from the different points of compass for the year 1871.

Stations.	N.	N. E.	E.	S. E.	S.	S. W.	W	N. W.
Superior City	4.4	35.0	2.9	2.0	3.2	21.6	10.8	12.3
Marquette	7.6	5.1	7.3	8.8	11.4	13.0	16.5	16.7
Milwaukee	2.0	18.3	3.1	16.5	1.1	28.2	9.7	9.1
Detroit	6.3	12.4	12.4	6.5	15.8	19.4	14.4	12.8
Monroe City	8.6	23.1	5.9	7.7	8.7	23.1	7.6	15.3
Cleveland	7.2	16.8	1.4	9.3	22.3	16.1	9.2	13.5
Buffalo	1.0	16.1	6.1	5.5	4.4	32.7	11.8	20.6
Fort Niagara	14.0	10.4	5.1	0.6	19.7	26.0	19.1	4.7
Charlotte	11.0	8.5	6.9	6.6	19.6	11.6	19.5	16.1
Sackett's Harbor	6.8	18.1	2.7	1.5	22.2	14.0	14.9	7.3

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Maximum, minimum, and mean barometrical pressure for each month for the year 1871, reduced to 32° Fahrenheit by 28 inches.

Stations.	JANUARY.			FEBRUARY.			MARCH.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior City	2.051	0.733	1.423	1.793	0.555	1.255	1.626	0.313	1.210
Marquette	1.995	0.710	1.342	1.684	0.395	1.205	1.694	0.440	1.172
Milwaukee	1.865	0.714	1.429	1.864	0.602	1.312	1.648	0.623	1.256
Detroit	1.976	0.827	1.493	1.895	0.708	1.390	1.671	0.853	1.316
Monroe City	1.941	0.833	1.460	1.765	0.652	1.322	1.667	0.860	1.278
Cleveland	1.851	0.831	1.418	1.784	0.650	1.329	1.586	0.863	1.262
Buffalo	2.007	0.858	1.467	1.826	0.451	1.354	1.660	0.862	1.295
Fort Niagara	2.371	1.230	1.860	2.246	1.201	1.762	2.086	1.261	1.711
Charlotte	2.456	1.234	1.823	2.179	0.970	1.690	2.027	1.133	1.627
Sackett's Harbor	2.508	1.214	1.855	2.258	0.784	1.714	2.024	1.161	1.645

Stations.	APRIL.			MAY.			JUNE.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior City	1.505	0.436	1.102	1.676	0.867	1.319	1.487	0.947	1.249
Marquette	1.578	0.465	1.073	1.603	0.989	1.305	1.511	0.783	1.201
Milwaukee	1.643	0.545	1.129	1.645	1.098	1.355	1.611	1.060	1.301
Detroit	1.775	0.778	1.223	1.700	1.069	1.402	1.597	0.985	1.332
Monroe City	1.729	0.773	1.180	1.594	1.061	1.359	1.568	0.953	1.296
Cleveland	1.707	0.729	1.171	1.582	0.976	1.319	1.524	0.988	1.269
Buffalo	1.724	0.792	1.207	1.674	1.062	1.352	1.562	0.843	1.285
Fort Niagara	2.233	1.212	1.622	2.132	1.408	1.754	2.005	1.212	1.675
Charlotte	2.176	1.078	1.535	2.048	1.344	1.669	1.829	1.136	1.591
Sackett's Harbor	2.158	1.252	1.594	2.013	1.314	1.662	1.841	1.151	1.589

Stations.	JULY.			AUGUST.			SEPTEMBER.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior City	1.550	0.957	1.242	1.548	0.705	1.232	1.724	0.792	1.385
Marquette	1.490	0.848	1.200	1.482	0.444	1.193	1.727	0.822	1.352
Milwaukee	1.583	1.002	1.312	1.565	0.775	1.304	1.784	1.156	1.485
Detroit	1.624	1.073	1.359	1.593	0.935	1.359	1.874	1.163	1.511
Monroe City	1.594	1.030	1.316	1.626	0.947	1.334	1.744	1.171	1.466
Cleveland	1.546	1.020	1.295	1.490	0.942	1.295	1.727	1.171	1.441
Buffalo	1.587	1.030	1.309	1.558	0.865	1.319	1.736	1.112	1.463
Fort Niagara	1.997	1.384	1.694	2.007	1.303	1.704	2.261	1.414	1.855
Charlotte	1.959	1.315	1.614	1.851	1.258	1.631	2.092	1.380	1.783
Sackett's Harbor	1.914	1.321	1.605	1.925	1.298	1.644	2.145	1.372	1.799

Stations.	OCTOBER.			NOVEMBER.			DECEMBER.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior City	1.572	0.700	1.220	1.757	0.867	1.395	1.835	0.547	1.314
Marquette	1.559	0.592	1.161	1.687	0.837	1.344	1.656	0.344	1.200
Milwaukee	1.680	0.833	1.322	1.769	0.989	1.396	1.832	0.572	1.343
Detroit	1.765	0.984	1.427	1.939	0.857	1.438	1.854	0.642	1.362
Monroe City	1.733	1.029	1.415	1.865	0.753	1.413	1.825	0.611	1.369
Cleveland	1.702	1.046	1.380	1.878	0.714	1.352	1.796	0.682	1.332
Buffalo	1.784	1.009	1.407	2.012	0.696	1.387	1.792	0.847	1.341
Fort Niagara	2.260	1.353	1.804	2.489	0.993	1.846	2.270	1.359	1.834
Charlotte	2.144	1.350	1.722	2.347	1.005	1.711	2.140	1.095	1.633
Sackett's Harbor	2.158	1.342	1.736	2.333	1.187	1.721	2.191	1.079	1.665

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Maximum, minimum, and mean barometrical pressure for seasons and year for the year 1871, reduced to 32° Fahrenheit by 28 inches.

Stations.	SPRING.			SUMMER.			AUTUMN.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior City	1.676	0.313	1.210	1.550	0.705	1.241	1.757	0.700	1.2[illegible]
Marquette	1.694	0.440	1.183	1.511	0.444	1.198	1.727	0.582	1.2[illegible]
Milwaukee	1.648	0.545	1.247	1.611	0.775	1.306	1.784	0.833	1.[illegible]
Detroit	1.775	0.778	1.314	1.624	0.935	1.350	1.939	0.857	1.[illegible]
Monroe City	1.729	0.773	1.272	1.626	0.947	1.315	1.865	0.753	1.[illegible]
Cleveland	1.707	0.729	1.251	1.546	0.942	1.286	1.878	0.714	1.[illegible]
Buffalo	1.724	0.792	1.285	1.587	0.843	1.304	2.012	0.696	1.[illegible]
Fort Niagara	2.233	1.212	1.696	2.007	1.212	1.658	2.261	0.993	1.[illegible]
Charlotte	2.176	1.078	1.610	1.959	1.136	1.612	2.347	1.005	1.[illegible]
Sackett's Harbor	2.158	1.161	1.634	1.925	1.151	1.613	2.333	1.[illegible]	1.[illegible]

Stations.	WINTER.			YEAR.			
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Range.
Superior City	2.051	0.478	1.329	2.051	0.313	1.27[illegible]	1.7[illegible]
Marquette	1.995	0.395	1.252	1.995	0.395	1.23[illegible]	1.6[illegible]
Milwaukee	1.865	0.561	1.359	1.865	0.545	1.32[illegible]	1.3[illegible]
Detroit	1.976	0.676	1.416	1.976	0.676	1.36[illegible]	1.3[illegible]
Monroe City	1.941	0.619	1.368	1.941	0.619	1.347	1.3[illegible]
Cleveland	1.851	0.548	1.355	1.878	0.548	1.321	1.3[illegible]
Buffalo	2.007	0.451	1.380	2.012	0.451	1.347	1.5[illegible]
Fort Niagara	2.371	1.175	1.778	2.371	0.993	1.76[illegible]	1.3[illegible]
Charlotte	2.456	0.970	1.713	2.347	0.970	1.669	1.3[illegible]
Sackett's Harbor	2.508	0.784	1.735	2.333	0.784	1.662	1.5[illegible]

Maximum, minimum, and mean temperature for each month for the year 1871.

Stations.	JANUARY.			FEBRUARY.			MARCH.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior	40	0	12.8	40	0	16.5	50	2	2[illegible]
Marquette	36.5	— 3	19.1	47	— 4	20.9	46	15	2[illegible]
Milwaukee	61	4	28.0	52	— 2	27.6	55	24	3[illegible]
Detroit	56	— 2	26.6	62	— 2	26.6	64	16	3[illegible]
Monroe	63	3	30.4	65	4	31.1	73	22	3[illegible]
Cleveland	63	8	30.1	66	4	29.6	73	25	3[illegible]
Buffalo	57	— 4	26.7	59	— 3	26.8	70	22	3[illegible]
Fort Niagara	55	0	23.8	57	3	25.2	60	22	3[illegible]
Charlotte	67	—16	26.3	59	—12	27.6	69	15	3[illegible]
Sackett's Harbor	55	0	22.2	54	3	24.6	68	12	3[illegible]

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Maximum, minimum, and mean temperature for each month for the year 1871—Continued.

Stations.	APRIL.			MAY.			JUNE.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior	59	19	36.2	87	25	49.8	88	37	58.4
Marquette	61	24	38.9	90	31.5	54.2	92	37.5	60.9
Milwaukee	84	30	46.1	90	35	55.4	85	45	64.4
Detroit	81	18	48.1	87	24	58.4	89	35	66.3
Monroe	87	28	53.5	96	32	64.0	95	44	71.4
Cleveland	85	27	52.4	93	37	61.2	90	48	69.0
Buffalo	70	28	46.2	92	30	55.4	88	40	65.7
Fort Niagara	75	26	45.7	87	38	56.1	87	44	63.9
Charlotte	81	17	47.2	90	28	57.0	93	34	65.6
Sackett's Harbor	73	19	46.6	83	32	55.2	88	42	64.8

Stations.	JULY.			AUGUST.			SEPTEMBER.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior	94	40	63.7	91	35	62.5	81	28	55.7
Marquette	90.5	42	65.9	90.5	42.5	66.7	86.5	31.5	55.2
Milwaukee	96	52	69.4	93	47	68.7	91	34	58.3
Detroit	90	38	69.8	99	42	70.5	89	23	58.5
Monroe City	99	46	75.5	100	53	74.5	93	29	63.9
Cleveland	89	53	71.7	88	53	71.7	80	40	60.9
Buffalo	88	49	68.0	90	46	69.6	80	31	57.5
Fort Niagara	89	55	68.8	88	54	71.0	85	39	58.8
Charlotte	96	42	69.8	93	43	70.7	92	25	59.1
Sackett's Harbor	88	50	69.3	90	48	70.6	85	29	56.3

Stations.	OCTOBER.			NOVEMBER.			DECEMBER.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior	64	20	44.0	.....	.....	.....	.....	.....	.....
Marquette	77	29.5	45.8	43.5	7	29.3	34	—17.5	13.4
Milwaukee	82	27	51.5	54	8	32.8	47	—13	18.1
Detroit	83	20	52.8	56	3	33.2	54	—21	22.5
Monroe City	86	28	55.0	59	8.5	35.5	53	—19	23.0
Cleveland	78	37	56.1	58	17	38.1	58	—11	27.2
Buffalo	77	27	52.4	66	8	31.7	57	—11	23.9
Fort Niagara	79	32	52.9	50	8	32.0	50	— 5	23.3
Charlotte	86	20	53.9	60	2	34.4	51	—15	26.2
Sackett's Harbor	77	24	50.6	59	—7	30.7	50	2	21.3

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Maximum, minimum, and mean temperature for seasons and year for the year 1871

Stations.	SPRING.			SUMMER.			AUTUM		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior	87	2	37.93	94	35	61.53	81	20	[illegible]
Marquette	90	15	41.5	92	37.5	64.5	86.5	[illegible]	[illegible]
Milwaukee	90	24	45.8	96	45	67.5	91	[illegible]	[illegible]
Detroit	87	16	48.46	99	35	69.86	89	3	[illegible]
Monroe City	96	22	53.66	100	44	73.8	93	25	[illegible]
Cleveland	93	25	52.23	90	48	70.8	80	17	[illegible]
Buffalo	92	22	46.66	90	40	67.76	80	[illegible]	[illegible]
Fort Niagara	87	22	45.73	89	44	67.90	85	[illegible]	[illegible]
Charlotte	90	15	48.06	96	34	68.7	92	2	[illegible]
Sackett's Harbor	83	12	46.66	90	42	68.23	85	[illegible]	[illegible]

Stations.	WINTER.			YEAR.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Superior	40	0	14.65	94	0	46.99
Marquette	58.5	— 4	21.63	92	— 4	42.765
Milwaukee	61	—10	26.23	96	—10	46.715
Detroit	62	— 9	26.90	99	— 9	48.408
Monroe City	65	— 8	30.43	100	— 8	52.355
Cleveland	66	— 2	29.70	93	— 2	51.105
Buffalo	59	— 4	26.96	92	— 4	47.145
Fort Niagara	57	0	25.66	89	0	46.795
Charlotte	67	—16	27.83	96	—16	48.43
Sackett's Harbor	55	0	24.73	90	0	46.37

Maximum and mean resultant velocity and direction of the wind for each month for the year 1871

Stations.	JANUARY.				FEBRUARY.			Mean.
	Maximum.		Mean.		Maximum.		Mean.	
	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.
Superior	N. 45 E.	39.0	N. 11 W.	1.3	N. 45 E.	31.7	N. [illegible] W	[illegible]
Marquette	S. 75 W.	22.3	N. 89 W.	3.0	S. 5 W.	27.3	S. 29 W	[illegible]
Milwaukee	N. 28 W.	24.0	N. 37 W.	3.7	S. 29 W.	18.0	S. 63 W	[illegible]
Detroit	West	8.7	S. 41 W.	1.1	South	14.7	S. 30 W	[illegible]
Monroe City	N. 45 E.	20.7	S. 75 E.	0.6	S. 45 W.	23.3	N. 62 W	[illegible]
Cleveland	N. 49 W.	19.3	S. 88 W.	2.0	S. 88 W.	26.7	S. 60 W	[illegible]
Buffalo	S. 43 W.	17.3	S. 56 W.	2.3	S. 70 W.	31.7	S. 53 W	[illegible]
Fort Niagara	West	24.8	S. 60 W.	3.1	N. 45 W.	21.3	S. 67 W	[illegible]
Charlotte	N. 76 W.	30.7	S. 67 W.	2.2	West	34.0	N. 74 W	[illegible]
Sackett's Harbor	S. 50 W.	4.0	S. 10 W.	3.9	S. 81 W.	52.3	S. 52 W	[illegible]

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Maximum and mean resultant velocity and direction of the wind, &c.—Continued.

Stations.	MARCH.				APRIL.			
	Maximum.		Mean.		Maximum.		Mean.	
	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.
Superior	N. 45 E.	51.7	N. 33 W.	0.6	N. 45 E.	75.0	N. 39 E.	1.4
Marquette	S. 45 E.	31.7	S. 41 E.	2.3	S. 6 E.	26.3	S. 89 E.	2.3
Milwaukee	N. 68 E.	7.3	S. 57 W.	0.3	S. 45 W.	20.7	S. 52 W.	1.7
Detroit	S. 11 E.	17.0	N. 13 W.	0.8	S. 52 W.	10.3	S. 3 E.	1.0
Monroe City	S. 21 W.	17.7	N. 20 E.	0.8	S. 51 W.	28.0	N. 31 W.	0.3
Cleveland	N. 45 W.	20.7	N. 89 W.	1.9	N. 63 W.	13.3	S. 74 W.	1.2
Buffalo	S. 67 W.	17.3	S. 86 W.	2.1	S. 82 W.	23.7	S. 63 W.	3.1
Fort Niagara	N. 45 E.	16.3	N. 25 W.	1.7	S. 15 W.	22.3	S. 64 W.	2.1
Charlotte	S. 78 W.	26.7	S. 79 W.	1.5	S. 40 E.	33.0	N. 53 W.	2.6
Sackett's Harbor	S. 83 W.	22.0	S. 55 W.	2.8	S. 45 W.	28.3	S. 44 W.	6.9

Stations.	MAY.				JUNE.			
	Maximum.		Mean.		Maximum.		Mean.	
	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles miles per
Superior	N. 45 E.	51.7	N. 44 E.	0.9	N. 45 E.	40.0	N. 15 W.	5.4
Marquette	S. 15 E.	32.7	S. 3 W.	1.5	S. 34 E.	44.3	S. 51 W.	3.2
Milwaukee	N. 9 E.	6.7	N. 30 E.	1.0	N. 23 E.	4.7	N. 37 E.	4.3
Detroit	N. 78 E.	10.0	N. 33 E.	0.7	West	7.2	S. 87 W.	0.5
Monroe City	N. 48 E.	18.0	N. 40 E.	2.0	S. 45 W.	16.3	N. 71 W.	1.8
Cleveland	North	25.0	N. 12 E.	1.5	N. 81 W.	19.3	S. 88 W.	0.3
Buffalo	S. 80 W.	7.3	S. 77 W.	1.8	West	24.0	N. 87 W.	5.1
Fort Niagara	N. 45 E.	28.3	N. 13 E.	3.0	S. 5 W.	15.7	N. 85 W.	1.6
Charlotte	N. 45 E.	31.0	N. 8 W.	3.6	East	24.0	S. 84 W.	2.3
Sackett's Harbor	N. 79 W.	30.0	N. 83 W.	3.4	S. 80 W.	33.0	S. 68 W.	8.4

Stations.	JULY.				AUGUST.			
	Maximum.		Mean.		Maximum.		Mean.	
	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.
Superior	N. 45 E.	35.0	N. 21 W.	3.0	N. 45 E.	28.3	N. 8 W.	2.5
Marquette	South	24.8	S. 44 W.	5.6	S. 36 W.	18.7	S. 72 W.	4.0
Milwaukee	N. 40 E.	4.0	S. 31 E.	0.7	N. 22 E.	4.3	N. 62 W.	0.2
Detroit	N. 27 W.	4.7	S. 77 W.	0.6	South	9.7	S. 39 E.	0.5
Monroe City	S. 82 W.	9.7	N. 79 W.	1.0	N. 45 E.	13.3	N. 49 E.	1.0
Cleveland	S. 29 W.	9.0	N. 88 W.	0.7	N. 79 W.	17.7	S. 75 W.	0.7
Buffalo	S. 49 W.	17.0	S. 67 W.	3.7	S. 71 W.	19.7	S. 67 W.	2.1
Fort Niagara	S. 86 W.	13.3	S. 62 W.	2.8	S. 16 W.	45.3	S. 72 W.	1.6
Charlotte	West	17.3	N. 75 W.	2.1	South	20.7	N. 47 W.	2.8
Sackett's Harbor	S. 45 W.	27.3	S. 47 W.	6.4	S. 13 W.	36.0	S. 51 W.	5.9

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Maximum and mean resultant velocity and direction of the wind, &c.—Continued.

Stations.	SEPTEMBER.				OCTOBER.			
	Maximum.		Mean.		Maximum.		Mean.	
	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.
Superior	N. 45 E.	27.3	N. 42 W.	2.4	N. 45 W.	41.7	N. 5 E.	
Marquette	S. 13 W.	37.7	S. 65 W.	4.0	S. 46 W.	19.7	S. 61 W.	
Milwaukee	N. 25 W.	5.3	N. 81 W.	1.0	S. 45 W.	7.3	S. 34 W.	
Detroit	North	9.7	N. 31 W.	0.2	S. 4 E.	11.7	S. 19 W.	
Monroe City	N. 45 E.	20.7	N. 13 E.	1.5	S. 62 W.	16.0	S. 32 W.	
Cleveland	N. 77 W.	26.7	N. 57 W.	1.6	N. 34 W.	16.0	S. 37 W.	
Buffalo	N. 45 E.	18.0	N. 71 W.	1.2	S. 82 W.	30.7	S. 62 W.	
Fort Niagara	N. 45 E.	38.3	N. 39 W.	0.7	S. 45 W.	51.7	S. 50 W.	
Charlotte	N. 45 W.	38.3	N. 35 W.	4.0	N. 45 E.	45.0	S. 32 W.	
Sackett's Harbor	S. 11 W.	29.7	S. 61 W.	3.8	S. 69 W.	32.3	S. 48 W.	

Stations.	NOVEMBER.				DECEMBER.			
	Maximum.		Mean.		Maximum.		Mean.	
	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.	Resultant direction.	Resultant velocity in miles per hour.
Superior	N. 45 E.	35.0	N. 28 E.	4.7	N. 27 E.	19.3	N. 71 W.	
Marquette	S. 45 E.	24.0	N. 61 W.	1.1	S. 38 E.	23.0	N. 86 W.	
Milwaukee	N. 45 E.	6.3	N. 8 W.	0.8	S. 37 W.	7.0	S. 73 W.	
Detroit	N. 33 W.	7.7	N. 1 E.	0.4	S. 11 W.	16.3	S. 56 W.	
Monroe City	N. 45 W.	21.3	N. 13 W.	2.6	S. 33 W.	26.0	S. 40 W.	
Cleveland	N. 45 W.	31.7	N. 64 W.	3.8	S. 22 W.	22.0	S. 59 W.	
Buffalo	N. 39 W.	16.0	N. 53 W.	2.3	N. 82 W.	31.3	S. 43 W.	
Fort Niagara	N. 45 W.	65.0	N. 42 W.	10.3	West	60.0	S. 72 W.	
Charlotte	N. 22 W.	35.0	N. 11 W.	5.0	South	43.3	S. 74 W.	
Sackett's Harbor	S. 73 W.	35.3	N. 81 W.	3.2	South	43.3	S. 60 W.	

Mean amount of cloudiness for months, seasons, and year, from 0 clear sky to 10, for the year 1871.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.
Superior City	6.90	5.33	6.43	7.30	4.40	3.93	2.47	3.[illegible]	
Marquette	7.67	8.93	5.47	5.37	3.43	3.20	2.[illegible]	2.[illegible]	
Milwaukee	7.20	.....	6.03	5.83	3.27	4.17	3.30	4.[illegible]	
Detroit	9.17	7.90	7.87	8.10	6.90	7.37	6.[illegible]	5.[illegible]	
Monroe City	7.83	6.00	6.07	4.97	3.63	3.83	3.50	3.[illegible]	
Cleveland	8.10	6.37	5.23	4.87	3.00	4.20	3.57	3.[illegible]	
Buffalo	9.17	7.97	7.23	6.63	5.00	5.17	5.10	5.[illegible]	
Fort Niagara	2.03	1.93	6.50	5.47	4.73	4.53	4.23	5.[illegible]	
Charlotte	9.13	7.70	7.50	5.87	4.47	4.57	5.13	5.[illegible]	
Sackett's Harbor	7.23	6.47	6.40	6.70	4.53	5.57	5.63	5.[illegible]	

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Mean amount of cloudiness for months, seasons, and years, &c.—Continued.

Stations.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.
Superior City	4.23	4.80	3.27	6.04	3.28	3.90	6.04	4.82
Marquette	5.33	6.23	5.43	4.76	3.31	4.90	5.80	4.69
Milwaukee	4.40	5.50	5.37	5.04	3.83	4.54	6.50	4.98
Detroit	8.70	8.50	9.17	7.62	7.41	8.21	8.66	7.98
Monroe City	3.17	5.07	5.30	4.89	3.59	3.99	6.72	4.80
Cleveland	3.97	7.33	7.27	4.37	3.82	5.27	7.43	5.22
Buffalo	6.80	7.27	8.07	6.29	5.16	6.30	8.71	6.62
Fort Niagara	8.97	9.37	9.63	5.57	4.33	9.11	2.09	5.40
Charlotte	6.27	8.33	8.53	5.95	5.19	6.48	8.44	6.52
Sackett's Harbor	5.83	6.53	7.97	5.88	5.51	5.79	7.32	6.13

Mean amount of rain or melted snow for months, seasons, and year, in United States. Inches for the year 1871.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.
Superior City	0.85	1.12	1.97	3.54	1.49	1.06	4.27	1.38	3.01
Marquette	2.37	1.18	3.89	2.51	1.78	2.66	2.04	2.06	3.07
Milwaukee	3.14	1.32	2.75	3.20	2.24	3.09	1.84	3.77	0.60
Detroit	0.84	2.13	2.44	1.67	1.90	3.32	1.79	1.46	1.14
Monroe City	1.64	2.51	2.63	2.19	3.01	2.40	2.48	2.43	0.33
Cleveland	1.53	2.21	3.22	1.75	1.88	3.58	3.03	8.03	1.00
Buffalo	1.24	2.00	3.08	2.62	1.68	3.40	3.70	4.86	0.82
Fort Niagara	1.07	1.22	3.21	1.53	1.18	1.59	1.44	1.98	0.82
Charlotte	1.60	1.43	1.76	2.40	1.16	3.40	2.73	4.42	0.56
Sackett's Harbor	1.07	1.22	3.21	1.53	1.18	1.59	1.44	1.98	0.82

Stations.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.
Superior City	3.46	1.46	1.05	2.33	2.24	2.64	0.72	1.98
Marquette	3.32	1.29	2.20	2.73	2.25	2.56	1.78	2.33
Milwaukee	2.72	2.40	2.03	2.73	2.90	1.91	2.08	2.41
Detroit	0.36	3.36	1.23	2.00	2.19	1.62	1.98	2.00
Monroe City	0.39	3.51	2.06	2.61	2.44	1.41	2.35	2.20
Cleveland	0.75	1.56	1.50	2.28	4.88	1.10	2.28	2.64
Buffalo	1.26	2.88	0.93	2.46	3.99	1.65	2.02	2.53
Fort Niagara	0.42	1.02	0.94	1.97	1.67	0.75	1.63	1.51
Charlotte	1.59	3.26	1.71	1.77	3.52	1.80	1.81	2.23
Sackett's Harbor	0.42	1.02	0.94	1.97	1.67	0.75	1.91	1.58

Mean amount of humidity for months, seasons, and year, saturation 1.000, *for the year* 1871.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.
Superior City									
Marquette			0.801	0.775	0.663	0.695	0.723	0.701	0.690
Milwaukee			0.662	0.617	0.591	0.636	0.607	0.661	0.615
Detroit			0.686	0.743	0.719	0.754	0.740	0.763	0.727
Monroe City			0.650	0.619	0.655	0.673	0.725	0.725	0.712
Cleveland			0.672	0.643	0.654	0.715	0.728	0.749	0.733
Buffalo				0.745	0.692	0.677	0.740	0.700	0.710
Fort Niagara			0.776	0.800	0.836	0.862	0.876	0.837	0.652
Charlotte			0.706	0.710	0.668	0.668	0.717	0.703	0.662
Sackett's Harbor			0.765	0.771	0.767	0.715	0.720	0.703	0.727

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Mean amount of humidity for months, seasons, and years, &c.—Continued.

Stations.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Mean.
Superior City	.....	.....	.....	.....	.....	.....	.....	.....
Marquette	0. 748	0. 807	.....	0. 746	0. 706	0. 748	.....	.....
Milwaukee	0. 574	0. 684	.....	0. 623	0. 635	0. 624	.....	.....
Detroit	0. 692	0. 776	.....	0. 716	0. 752	0. 732	.....	.....
Monroe City	0. 728	0. 753	.....	0. 641	0. 708	0. 731	.....	.....
Cleveland	0. 650	0. 676	.....	0. 656	0. 731	0. 686	.....	.....
Buffalo	0. 688	0. 774	.....	0. 718	0. 706	0. 724	.....	.....
Fort Niagara	0. 628	0. 556	.....	0. 604	0. 858	0. 612	.....	.....
Charlotte	0. 641	0. 740	.....	0. 694	0. 702	0. 681	.....	.....
Sackett's Harbor	0. 739	0. 771	.....	0. 768	0. 713	0. 746	.....	.....

APPENDIX L.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, May [illegible], 1871.

MAJOR: I have the honor to submit the following report of the operations of the parties under my charge during the past season, accompanied by such recommendations as have been suggested thereby.

The following orders were received for the summer campaign, viz: "To proceed to Ogdensburg, &c., to take charge of the survey of the Saint Lawrence and of the shore parties of Messrs. Lamson and Towar.

"To base the survey on a carefully executed secondary triangulation; to be governed in this work by the principles of primary triangulation, and to avoid bad atmospheres in reading the angles."

On the 23d day of May I left Detroit, accompanied by Mr. Von Schrader, one of the recorders, and stopped at all the prominent points between Lake Erie and Lake Champlain, in search of steamers suitable for the work. The steamer Grand Isle, belonging to Mr. Andrew Williams, of Plattsburg, was the only large one that could be found at all suitable for the purpose.

She was hired for $18 per day; the owner agreeing to take the responsibility of any accident that might happen, unless in extreme cases specified in the agreement, and also to keep the boat and machinery in repair.

No other could be found for less than $40 or $50 a day, and many offered at these rates were smaller and all less serviceable than the Grand Isle. She measures 110 feet in length, 23 feet beam, and draws from 6 feet light, to 7½ when loaded with the usual supply of coal, and burns about 2 tons of coal a day when running ten hours, at the rate of from twelve to fourteen miles an hour.

Another small boat 30 feet long, 9 feet beam, and drawing 2½ feet of water, was offered for sale at Buffalo for $700. This was suitable to be used as a tender for the larger steamer. I accordingly applied for authority to purchase it, but during your absence at Lake Superior the clerk intrusted with this correspondence neglected to attend to it, and being left in doubt as to the result of my application, I hired two other boats, with the understanding that they should be paid for at the rate of $10 a day if employed a week or two, and $8 per day if employed during the season. This included the pilot and engineer. About the 10th of July I received an affirmative answer to my application, with a check for $700, and having authority to proceed to Buffalo to buy the boat, I did so, but the experience acquired in the mean time of the difficulty of operating with row-boats in the swift waters of the Saint Lawrence induced me to retain the two steamers already hired for the shore parties, and put the new one to use in reconnoitering in connection with the Grand Isle.

The Grand Isle herself required extensive repairs in order to render her serviceable, and though, if it had been necessary to make these at our own expense, they would not have increased the total cost of the boat to as much as $25 per day, yet her owner was liberal enough to make most of them at his own expense.

The confusion which resulted from having mechanics on board was the cause of much loss of property, swept overboard among the shavings, &c., and there was no room to make a closet large enough to hold the tools and keep them under lock and key; but after all the necessary changes were made, the steamer was suited in all respects for the uses of the survey, and is recommended for further employment.

The small steam-launch will require some repairs to her hull before use for the coming season, but will last several years before wearing out. Some of the small boats will require painting, and others calking.

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Messrs. Lamson and Towar were established in camp near each other, and a few miles above the head of the Long Sault Rapids, about the 1st of June, and by the 5th my own party, recruited partly in Plattsburg, where the boat was hired, and partly in Ogdensburg, was ready to commence work.

The country in the neighborhood of the river, below Ogdensburg, offers great difficulties to a good system of secondary triangulation. It is low, very gently rolling, about half wooded, and the trees very much higher than the undulation of the ground. The river itself is broken by a number of small islands, most of them thickly wooded, so that it is quite narrow; and no long lines can be obtained unless by erecting very high and expensive stations, so as to see over the tops of the trees, and the lines obtained by a system of small triangles would be so short that it would require the work of several seasons to measure all the angles to within the degree of accuracy required. To build stations large enough to see over the tree tops would involve an expense altogether out of the question.

At first it was thought that stations could be built of unhewn timber obtained upon the spot, in the same manner as upon the upper lakes, and about ten days were expended in the construction of one upon Long Sault Island, but the difficulty of working in hard wood, which alone can be obtained in this region, and that but in few places, did not encourage a continuation of this process. It was, therefore, thought practicable to build stations with a 10-foot center-post, and to select spots for these by taking advantage of intervals between the woods, so as to give lines a mile or so in length; but a little experience in this very peculiar country soon showed that the labor and time required to solve this intricate puzzle involved a greater expense than any other method. The intermediate system described below was, therefore, adopted.

A strong effort was made to get the triangulation so far in advance of the shore parties as to be able to furnish them with points as a basis for their topography, after the manner indicated in the general discussion which follows. For this purpose, and in order better to attend to the wants of the shore parties, the steamer usually operated in the same field with the former; and while in the neighborhood of Ogdensburg the shore parties made use of the stations built by the steamer's party as the basis of their work; and for a week or so Mr. Towar observed the angles at the stations in the neighborhood of his own camp, using a ten-second Gambey, furnished by the steamer party.

For a week or more, in the months of June and July, the steamer was detained in Ogdensburg for repairs, from accidents necessarily arising in such duty as that upon which she was engaged; and this time was occupied in reconnoitering the country in the vicinity, and a number of stations built both above and below Ogdensburg. In this part of the country the river is a little over a mile in width, and as it is only partially wooded, the ground sloping toward the river on both sides, it offers a most illusive prospect for obtaining triangles with sides of two or three miles in length; but after trying every possible combination, it was clearly proved that no such system of triangles could be obtained, for the clearings are made in so peculiar a manner that lines parallel to the direction of the river could so rarely be found that the continuity of the system could not be kept up, and at length, with two exceptions, stations were selected upon the banks of the river.

At Chippewa Point the river begins to widen, and the country is not unfavorable to triangulation.

In the lower part of the river the hostility of many of the natives, more especially on the Canada side, increased the labor and expense of the work, for on this side they often tried to drive us off their premises, and would not allow their trees to be cut down upon any consideration or for any price; but were too much afraid of us to attempt to tear down any of our stations. The officers and agents of the General Government, however, treated us with a courtesy which was very gratifying.

From the last week in July until the middle of November the smoke from the burning forests became very dense, and it was only at long intervals that any work could be done at all. This was more especially the case below, for Lake Ontario was only obscured for a few weeks.

Accordingly, about the middle of August, Mr. Von Schrader was left at Mr. Lamson's camp, four miles above Ogdensburg, to take advantage of any good weather that might present itself to observe the angles from stations already built. We had only eight or ten days of good weather, but measured angles for about ten miles above Ogdensburg, as well as could be expected under the circumstances. He rejoined the steamer on the 6th of October.

Mr. Gillespie was left at Mr. Towar's camp, four miles below the city, to build stations in that region, and on the 13th of September he was established in a camp of his own, below Waddington, to put up signals to mark the spots where stations should be erected, (their general position having previously been determined by me,) and to measure a base-line on the Grand Trunk Railroad opposite.

Meanwhile, with the Grand Isle, I continued the main reconnaissance up the river and in the eastern part of Lake Ontario, where the air was clearer.

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This reconnaissance was completed as far as Oswego by the 1st of October, when it became necessary to aid the shore parties in their sounding. The atmosphere at this time was so smoky that any other kind of work would be altogether out of the question.

The maps accompanying this report show the system of triangulation which was finally adopted. The numbers attached to the stations indicate the height of the center post, and where the stations have not yet been built these numbers are inclosed in parenthesis. The heavy lines indicate the base-lines at Maple Grove, Morrisburgh, and Ogdensburg, respectively. Another will be required near Brockville, but its position has not yet been accurately determined, and it will probably be well to measure one also at Cape Vincent or Sackett's Harbor. A system of small triangles serves to connect the base at Maple Grove with the iron posts at Saint Regis, which mark the boundary line between the United States and Canada, and whose latitude and longitude were determined by the commissioners who established this boundary. From Maple Grove to Ogdensburgh most of the stations have either 10 feet or 20 feet center-posts, four have 35-feet center-posts and two 60-feet center-posts, one of which latter is that heretofore alluded to as being built of unhewn timber by the steamer-party on Long Sault Island. Between Ogdensburg and Chippewa Point all the stations are small and placed on both banks of the river.

From Chippewa Point to Carleton Island good triangles are obtained with stations having 20 feet or 35 feet center-posts. The last two that have been built are those on Carleton and Wolf Islands.

A scheme of triangulation, which it is proposed to connect with these stations, is shown on the chart by broken lines, but the position of the points x and y may have to be slightly altered.

On the chart of Lake Ontario accompanying this report a system of triangulation for the eastern end of the lake has been indicated in full lines. No stations have been built upon the lake, but flag signals have been erected at points where they were required to aid in the reconnaissance. There was not time enough during the past season to ascertain with a level the height of the hills near Sodus and Oswego, and the following data are all that have yet been obtained in determining the height of center-post necessary to be given at these two points. From a point thirty miles northwest of Oswego, the eye of the observer being 15 feet above the water, the following points appear just above the horizon on a very clear day: Dry Hill, near Watertown, New York; a hill just outside Oswego, toward the east; Sodus Bluffs; Peter's Point, Canada, and Duck Island. (Probably a station of 120-feet center-post on Peter's Point, with one of 75-feet center-post at Oswego and Sodus Bluff, would suffice.) It is said that, under favorable circumstances, Duck Island can be seen from Fort Ontario. To the west of these points, and as far as Devil's Nose, the lake is wider and the bluffs no higher, and very high stations would have to be erected (probably 180 feet at least) on both sides of the lake in order to see across, but beyond this point the banks begin to grow higher and the lake narrower. Possibly it would be as economical to use a system of smaller triangles between the southern shore of the lake and the high ridge which crosses the Niagara River at Lewiston, and the Genesee River at Rochester.

A system of primary triangulation suitable for connecting the work on the Saint Lawrence River with that on Lake Champlain was fully explained in my report for June.

The base-line at Ogdensburgh was measured twice with the secondary-base apparatus, and once with the walnut rods. The two measurements coincided.

The base at Morrisburgh, 8,580 feet long, was measured twice with the base-apparatus, and the measurements agreed to within less than half an inch after applying the correction for temperature, and the measurements made with the walnut rods did not differ by more than a few inches from each other, but made the distance about a foot shorter than the base-apparatus.

At Maple Grove the trains were constantly passing, and no complete measurement was made.

The hydrography of the lower part of the river presented difficulties of a peculiar nature, and it was necessary to employ my own party to assist the shore parties in this work, where the water was too swift to be sounded in the ordinary manner. At two or three points these rapids had been partially examined in the year 1854 by Messrs. Maillefert and Raasloff, who were employed by the Canadian government to make a survey of the various rapids of the Saint Lawrence River with a view to their improvement for the purposes of navigation, by submarine blasting. They employed several methods of sounding. In some places they were able to make these soundings from small boats let down by means of ropes from scows anchored in the stream above the rapids, but for the more violent portions a barge was constructed of boiler-iron, from the deck of which soundings were taken at intervals by means of poles, and other poles, reaching, to various depths, were lashed vertically to the sides of the barge. In sounding by hand, however, many rocks of the largest size might be passed over, owing to the rapidity with which the barge was carried along by the current, while the immovable

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poles, once broken, became useless for further investigation, and the evidence furnished in either case must be of a partial and unsatisfactory nature.

In order to furnish continuous lines of soundings and determine completely the form and nature of the bottom, an apparatus was devised of which a more complete description is given in the general discussion which follows. The scow to which this apparatus was attached being towed to the head of the rapids, was then let go, and carried through them by the force of the current, when it was picked up by a tug and brought back through the canal. The varying winds were found amply sufficient to give to its course as many different directions as were desired, and by taking them into consideration, in connection with the different points at which the scow was let go, it was found practicable to cover the ground without difficulty. Two or three observers, stationed at different points along the shore with theodolites, located the course of the scow, while others read the graduated scale. Since in all former surveys of the rapids several lives had been lost, it was not deemed advisable to man the scow, which, from the nature of the operation, would be altogether superfluous.

Four lines only were run by the 7th of November, when the weather became so cold that we had to break up, but in order to complete the work four more should be run, and the water below, to within a mile of the foot of Barnhart's Island, sounded at the same time. The scow should also be passed down the Rapid du Plat two or three times and the Gallops three or four, to see if any shoals have been passed over in sounding with the lead.

In sounding the swift waters from about a mile above the head of the Gallops Rapids down to the foot of the Rapids du Plat, we made use of the fourth method of locating the soundings mentioned in the general discussion which follows. Ranges were established on the left bank of the river and an angle observed at the moment of crossing each range, either with a sextant on board ship, or a theodolite on shore. In the South Sault, a very circuitous, rapid, and narrow channel, soundings were taken from two small tugs and a small boat which drifted down the stream abreast, or nearly so, and the position of each sounding plotted on the spot, by inspection, upon the topographical chart already constructed, and it is believed that greater accuracy was attained by this means than would have been practicable by any artificial method. In other places, where the water was comparatively still and the stream wider, the soundings were located either by the first * or third † methods indicated in the general discussion, though it is probable that much time would have been saved had the third method alone been employed in almost every instance. Where the stream was narrow and shoal, and the water comparatively still, lines were run back and forth to and from stations on the opposite banks, and soundings taken on time.

On the last passage of the scow down the North Sault Rapids, the men intrusted with letting it go from the steamer were frightened, and neglected to drop the steering-chain, so that the scow got foul of a rock in the rapids, and the iron rod was carried away.

After one 60-foot station, three 35-foot stations, and a number of smaller ones had been built by the steamer-party, the work had reached such a state that the same party could not attend to reconnoitering and building stations, and the latter work was accordingly given out to Mr. Pope, of Ogdensburg, he being the lowest bidder. His rates were very high, but under the circumstances the choice lay between accepting them and leaving the work undone.

With a steamer upon which the party can live, I believe that it is more economical to build stations ourselves, but not without.

The work of the shore parties was ably conducted by Messrs. Lamson and Towar. The amount has been stated by each in his special report.

Their energy and zeal are deserving of mention. The nature of their work was peculiar, and Mr. Towar, particularly, showed great skill in adapting himself to the circumstances.

RECOMMENDATIONS.

It is observed that where a number of men are employed year after year upon the same or similar work, as in the survey of the upper lakes, they are apt to form strong prejudices for the peculiar methods to which they have been accustomed, and in entering upon a new field much additional expense would be incurred on the survey, should they attempt to apply these methods where the face of the country and the nature of the water to be surveyed present circumstances of an entirely different character. These remarks apply more especially to the duties of the shore parties upon the lake survey as well in the matter of tertiary triangulation as in topography and hydrography.

The features of the country upon which they have hitherto been employed have been of a peculiar nature. In many instances triangulation has been impracticable, and the only method that could be employed with economy has been to establish a series of

* Two theodolites. † Two sextants.

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stations along the shore, 2,000 feet apart, the distance between them being cha... The shore-line and the neighboring banks are sketched at the same time, and, by means of a theodolite with stadia attachment, a few lines are run back into the country about half a mile, and the topography roughly sketched in a note-book.

For the hydrography one or more intermediate stakes set up between the stations already referred to, in connection with one or more lines of buoys set out about half a mile from shore, and nearly opposite these stations and stakes, serve to mark the ends of lines of soundings. Six-oared boats are then rowed back and forth between these points, soundings are taken on time, and in plotting are proportioned between the two extremities of the line. On each of the stations previously mentioned a theodolite is set up, and one or two series of readings taken to all the other stations and buoys that are visible from it, and then these stations are well located by using the direction and the chained distance from the preceding station, and the shots taken to the buoys and the different stations form a number of small triangles which serve as a check upon the chaining. In other instances a good tertiary triangulation has been obtained, as when the coast has been rocky so as not to admit of chaining the shore-line, surveyed by means of a theodolite with stadia attachment. But these systems are altogether insufficient in a survey like that in the neighborhood of the Saint Lawrence River and Lake Champlain, and it is quite essential to a vigorous prosecution of the work that all the assistants and sub-assistants engaged in this section of the country should be thoroughly conversant with all the different methods of topography, hydrography, and tertiary triangulation which have been or may be employed, and the following hints will enable them to understand most readily the relations and advantages of the different methods applicable to such a survey.

I. DETERMINATION OF POINTS.

Points may be determined—

1. From a primary or secondary triangulation with a carefully measured base.
2. From a tertiary triangulation made by the shore party.
3. From intersections with the plane-table.

II. TOPOGRAPHY.

The topography may be filled in—

1. By running a line with a theodolite the distances upon the course itself measured either
   (*a*) By a chain, or
   (*b*) By stadia;
   and points to the right and left of this course located,
   (A) By intersections from two or more positions; or,
   (B) By stadia;
2. By plane-table distances being measured and points determined in the same manner as with the theodolite;
3. By means of a sextant used in connection with a chain;
4. By means of a sextant alone;
   obtaining two independent angles between known points.

III. HYDROGRAPHY.

1. Soundings may be taken by means of—
   First. By a lead-line.
   Second. By a pole held in the hand.
   Third. By the automatic sounding-apparatus.
   Fourth. By one of the deep-sea apparatus.
2. Positions of the boat may be located—
   First. By one or more observers from shore with theodolite or plane-table.
   Second. By one theodolite or plane-table on shore, and a sextant-angle taken on board.
   Third. By means of two independent sextant-angles taken on board.
   Fourth. By means of a range fixed by landmarks, natural, or established for the purpose, and by an angle taken either
      (*a*) By a sextant on board; or,
      (*b*) By an instrument on shore.
   Fifth. By fixing points on the water, either
      (*a*) By setting out buoys; or,
      (*b*) By establishing ranges on shore so as to intersect at convenient points upon the water.

It is not always essential in any of these methods to fix the position of all the soundings instrumentally, for when the rate of the boat is nearly uniform, by recording the

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time at which each sounding is taken, this will serve as the means of proportioning the distances between two determined points.

Although most of the assistants in charge of shore parties may be familiar with many of these methods, it is very essential for economy in conducting the survey that they should in each particular case be prepared to practice without bias or prejudice in favor of former methods, that one which will at the least expense produce the best results.

TRIANGULATION.

Whenever practicable the primary or secondary triangulation, from a base carefully measured by either of the apparatus now in use on the survey, should be first completed. From the points so determined, it is desirable, by a system of triangles constantly diminishing in size, to fix points upon the ground by means of small stations at distances not more than a mile or two apart, and these points, whose co-ordinates shall have been determined by calculation, should be plotted upon the sheet in the field, upon which all the topography should be sketched in pencil, and, if possible, the hydrography also be plotted before leaving the field. But, unfortunately, it has not always been practicable upon the Lake Survey for the triangulation to precede the other work, and the shore parties have almost invariably been compelled to establish points for themselves.

The methods of measuring angles, building stations, &c., being fully described in the "Instructions for Primary and Secondary Triangulation," with which all the parties are furnished, it is only necessary to notice further under the subject of triangulation some improvements which have been introduced in the method of using the secondary-base apparatus.

A secondary-base apparatus similar to the one used by the Coast Survey was constructed in Detroit during the spring of 1871, and though not as carefully made as could be desired, gave good results. No tripods or stands, however, were used in connection with it, as it was practicable and convenient in every instance to lay the apparatus upon the railroad-track. For a description of this base-apparatus see Coast-Survey report for 185–. The method of using the bars upon the railroad-track is as follows: The rear man at each bar is furnished with a wooden wedge, nine inches long, two and one-half wide, half an inch in thickness at one end, and an inch and a half at the other. The man who carries the head of the bar is furnished with a rectangular block of wood, eight inches long, two and a half inches wide, and one inch in thickness. Before starting out two stakes are driven in the ground, each side of the rail on which the measurement is to be made, and opposite to each other, and a mark made on the head of a tack driven in each of these stakes. The intersection of the line so marked with the center of the rail will be the starting-point, and it is well also to make a scratch on the side of the rail with a file or cold-chisel as a further precaution.

The first bar is then placed in position over the track, resting upon the block and wedge placed respectively at a distance of about six inches from the two ends of the rod, and held firmly in this position. The second rod is now brought up and held as follows: As soon as the man to the rear, who carries the wedge and holds that end of the rod to which the micrometer-screw is attached, shall have placed his end of the bar down on the track in about the correct position, the head man places his block under the bar at a distance of about six inches from the end. He supports the bar by this block, facing in the direction of the measurement, one hand on each side of the bar. Resting the ends of his thumbs upon the railroad-track behind the block, he raises the bar with the ends of his fingers, keeping his knuckles to the front. By this means the rod will be perfectly free to move back and forth at the will of the other man, and great care should be taken that the man holding the block does not restrain the bar in any way, except to keep his end of the rod over the middle of the track. The man holding the wedge, who carries the rear end of the apparatus, viz, that to which the micrometer-screw is attached, now makes the contact with the other rod, sliding his wedge up and down, observing to get his rod precisely on the prolongation of the other one, and the marks upon the indicator nearly co-incident. He then gives the command, "Steady." At this command the head man places his end of the rod over the center of the track upon which the block now rests, taking care to hold the bar so that its sides shall be vertical. After the command, "Steady," has been given, this man is responsible for maintaining it in position.

He will therefore tightly grasp the rail and block with his fingers and place the knuckles of his thumbs firmly against the bar, resting them upon the block. Should the rear end of the rod be moved slightly by this means, the man holding the wedge will correct the error, and then place his hands in a similar manner to those of the head man, so as to aid him in keeping the bar in position. The chief of party now completes the contact by means of a microscope, either held in his hand, or attached to one of the bars.

Meanwhile the recorder has been observing the thermometers in the first bar. The contact completed, the chief of party gives the command "Break," at which the

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first rod is drawn slightly backward, then lifted from the track and carried forward where it is put in position in the same manner as the second rod. It is not necessary to use the level with this apparatus, for should the grade be very steep or irregular it would be better to determine the grade of the rail itself by a leveling-instrument.

In this way three or four miles may be easily measured in a day with a probable error not greater than 1 in 150,000. Upon the Saint Lawrence River two independent measurements of a line of 8,000 feet agreed, when corrected for temperature, to within less than half an inch. Two forms of this apparatus were constructed; in one the wooden casing measured 3 by 3 inches in cross-section, and in the other 3 by 6 inches. The smaller size was found to be more convenient and amply rigid. A theodolite was at first carried along to cut off the end of the measurement when trains passed, but it was found that in any position from which the rail was visible, the theodolite was no more disturbed than the rail itself. On a well-made road the ties are not materially moved by the passage of the trains, and by making a scratch upon the top of the track and another at the junction of rail and tie, the point can be marked pretty well: but if a greater degree of accuracy be required, pegs must be driven in the ground whenever trains passes, as mentioned above, or a day selected for the purpose when no trains will be passing. Upon the Great Western Railroad, near Windsor, when measurements were made in cold weather and the ground was frozen, no perceptible motion was discovered in the ties, and in many instances none in the rails themselves. But on the Grand Trunk Road, near the Saint Lawrence, the case was very different, and the track could in several instances be distinctly seen to move an inch or more backward when the engine passed over it, and as far forward from its original position after a few cars had passed.

Simple walnut rods, of the form usually employed, are very convenient for making measurements along the railroad-track, either to serve as a base of a tertiary triangulation, or for more extended use in measuring long lines, and thereby dispensing with triangulation altogether. These have been used along the railroad-track at the rate of two miles an hour, two successive measurements on a line, 3,000 feet long, agreeing with each other to within less than half an inch. They should be armed with metal ends, and are worthy of careful examination as to the amount and nature of their contraction and expansion in different hygrometric conditions of the atmosphere. Perhaps it might be well to keep them absolutely wet.

Whenever stations are built by the parties themselves, under direction of an assistant, the survey, he should bear in mind that the chief duty of a constructing-engineer consists in so arranging and dividing the work that one man will never be obliged to wait for another, and that this can only be effected by going through the whole process beforehand in his imagination. In this way any piece of work can always be so arranged by a good engineer, whereas if left to a foreman or master-workman to superintend, however skillful he may be in his own peculiar line of duty, there will always be a large fraction of the men waiting for the others. When thirty or forty men are employed at the average rate of $2 a day, no agent of the Government has any right to neglect this precaution. The Appendix A shows how the work of building a station is apportioned in this way.

TOPOGRAPHY.

Whenever the plane-table can be used to advantage for topography, its superiority to all other instruments is palpable to any experienced and unbiased mind. The various methods of using it, and of establishing points by means of measurements, intersections, prosections, resections, &c., can be learned from any of the elementary treatises upon its use, and it would be well for those who are to use it to read carefully the article on this subject by Mr. ——— ———, which will be found in the Coast-Survey report for 1865; but the three-point problem referred to in this treatise should never be made use of unless in cases of extreme urgency, and even then it is much better to use, instead of this objectionable method, a piece of tracing-cloth or paper on which the angles between two points may be constructed graphically by means of the alidade. Much time may be saved by using a large steel triangle in connection with the alidade as follows: in orienting the plane table, place one edge of the triangle alone the line upon the paper which is used to orient upon, its apex being at the point upon the paper which represents the station occupied; then place the alidade against the other edge of the triangle and orient in the usual manner. All lines upon the paper will by this means be at an angle to the corresponding lines upon the field equal to the angle between the two sides of the steel triangle thus employed, and by directing the telescope upon any other point after the plane-table is oriented, and applying the same edge of the triangle, much time can be saved, for in most instances it will not be necessary to place the edge of the alidade precisely over the point which represents the station occupied, but place it near this point, sight at the object whose line of direction is to be determined, then apply one edge of the triangle to the rule of the alidade, slide it along until the other edge passes through the point representing

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the station, and draw the line. It is evident that this will be the line of direction desired. In orienting the table upon the stake which marks its last position, if the distance is very short care must be taken to put the apex of the triangle directly over the point on the paper which represents the stake occupied. By using this method 120 points have been accurately located in one hour, the direction being laid off by this method points and the distance determined by the stadia attachment, and laid off upon the paper from a scale.

The telescope of a plane-table should of course always be furnished with cross hairs adapted to be used with the stadia-board, and a plane-table without this accompaniment is not recommended for use upon the survey under any circumstances. It is desirable that at least half a dozen points, distant from each other not more than a mile or two, should be plotted by co-ordinates upon each plane-table sheet before it is used. Set up the plane-table near one of these stations, say 30 feet distant if the scale be one ten thousandth, and on a range with another station plotted upon the sheet. Orient upon the latter station, then locate the point by section from a third station if any such be visible, but if not, by laying off the distance from the nearest station with the dividers. Then construct lines of direction to all stations visible from this point. The topography in the immediate neighborhood of this station may now be sketched in upon the sheet, and the detailed topography in the neighborhood proceeded with, provided that the stations whose positions have been plotted by co-ordinates are so situated that one or more of them may be seen from all or most of the positions that will be occupied in this operation. It is not advisable to run long lines with the plane-table without having some such points to serve as a check upon the work if the nature of the country will admit, and, if the points already plotted are not sufficient for this purpose, it will be best to set up the instrument at several points upon the field in the manner indicated above, and to plot the position of auxiliary stations by intersections from three or more points. When this is done, the details are filled in as follows: A forward course is selected by the most intelligent of the rod-men, who holds his stadia-board vertically over the point selected, which should not be more than a thousand feet from the present position, driving a peg in the ground to indicate the place where the plane-table is to be set up. The line of direction to this point is then drawn *clear across the paper*, and the distance read by the stadia carefully laid off on this line. The plane-table is then removed to its new position and oriented upon this line. Sights are then taken to one or more distant stations, to serve as a check; and no error in the work should be admitted greater than the thickness of the finest pencil-line; and, should any such error be observed, it should be corrected before proceeding further. It will seldom, however, be necessary to move the instrument, for, unless the stadia-attachment be inaccurate, if the error be in distance it can be corrected by sending a rod-man back to the last station. If the point on the plane-table be not accurately placed over the stake, this will be detected by using the plumb-bob. If not detected by either of these methods, it is evident that the error lies in erroneous plotting at the last stake of the line of direction itself, or in an inaccuracy of construction of the stadia-board or wire. The latter sometimes becomes loose, and, in this case, great care must be taken to investigate this very carefully before proceeding further. If the error in direction was slight and the distance from the last course short, orient the plane-table upon some distant station whose line of direction is nearly perpendicular to the course passed over, sight at the stake last occupied with the alidade, draw a new line of direction through the point representing the last stake, laying off upon it the proper distance, and this will give an approximate determination for the new point. Now draw several lines of direction through distant stations, and if all pass through the point newly plotted, t o within the desired degree of accuracy, it will be safe to proceed from this point. Should this method fail it will generally be preferable to return to the last station rather than try a new approximation or resort to the three-point problem, and by adopting this rule the source of error will best be discovered, and a habit of accuracy acquired which cannot be obtained in any other way. When the instrument is set up in its second position, the topography in its immediate vicinity is sketched as follows: The party should consist of at least four hired men, one with stadia-rod, hatchet, and pegs to select forward courses, two men with stadia-rods to establish points to the right and left, respectively, and one to carry the plane-table from point to point, and when the instrument is in position this man may hold the shade over it, or by means of flag signals deliver orders to the stadia-men. The following system of signaling to stadia-men has been found exceedingly convenient and applicable to all cases:

A separate flag is used for each man. The flag held upright indicates that the rod-man is to move from the instrument; the flag held downward, that he is to come to the instrument; pointing horizontally to the right or left, that he is to move in that direction, but not increase or diminish his distance from the instrument; held obliquely, his movements should correspond; thus, if the flag is held upright, but inclining slightly to the right, he is to move from the instrument while slowly gaining ground to the right, &c. It has been found in practice that the most stupid of the men employed as rod-men will pick up this method in two or three lessons. When the rod-

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man has arrived at the desired point, the flag is waved vertically three times, ... care to hold it directly in front of the body, and the flag-man always careful ... directly toward the man to whom he is signaling. If the rod be not held ver... a waving of the flag will indicate the side toward which he should incline it. W... determining the position of this man with the instrument, the flag-man makes sig... to the other rod-man, using a different flag for this purpose, and puts him in po... When the position of the first man has been determined, his flag is waved success... from side to side, indicating that he may shut up his stadia-board and prepare to ... a new position.

The best points to be determined by this method are corners of fences, houses, ... &c., and points along the shore or on the banks of the stream, and all neighb... stakes that have not been previously located should always be so determined. ... points should be taken by this method more than 1,200, or in extreme cases 1... feet from the instrument. If no such objects as those above mentioned present th... selves, trees, prominent rocks, or stakes conveniently placed will assist the ... sketching in the topography. A number of points having been fixed upon the s... the ground in the immediate neighborhood of the instrument is then sketched in ... the pencil, and a forward course taken as before. If it is purposed to run a lo... with the plane-table back from shore, it is advisable to measure the vertical a... upon the principal course and determine the elevation of the successive points a... this course by the ordinary method; for other points it is not recommended to ... the vertical angle unless it be great enough to make a reduction necessary in d... mining the horizontal distance, but all the horizontal curves should be filled in ... the hand-level. Although there are several other methods of using the plane-... which are equally correct theoretically, in ninety-nine cases out of a hundred thi... be found to be the most expeditious and accurate. The objection to the use of ... three-point problem lies chiefly in the loss of time and the confusion that results ... cutting up the paper by so many auxiliary lines, but in passing over a number of ... courses, such as the edge of a rocky island, it will usually be better to orient the p... table upon some distant object, where such is to be found, rather than upon the last station.

Where the country is densely wooded, and only accessible by means of a long ... circuitous road, as is frequently the case on the upper lakes, the theodolite with ... attachment will answer as well, the notes being taken in a note-book accordi... the ordinary method employed upon the survey. In this case the topography ... all be plotted in camp upon the succeeding day by the assistant detailed for that pur... pose. In a more open country, where a plane-table is not at hand, a very good ... stitute is a theodolite and stadia used in connection with a small drawing-board and ... sheet of cap paper with a graduated circle printed upon it. This method has ... long time been successfully employed upon the survey. No advantage can in any ... be claimed for it over a plane-table, except that it is perhaps a little more port... In this case, as in all others where the final sheet is not taken into the field, ... time will be saved in sketching the topography with colored pencils. In sketch... the details of cities, villages, &c., the chain will be found more convenient than ... stadia when used either with the plane-table or theodolite.

Where it becomes necessary to draw the distance along shore from one station ... another, from the impossibility of triangulating, the following mode of sketching ... country in the neighborhood of the shore will be found most convenient. Let one ... the chain-men, or a laborer detailed for the purpose, place pegs or other marks at ... tances three or four hundred feet apart, and from angles taken with the pocket-sextant ... to and from these pegs and other stations, locate as many auxiliary points as may ... required, and at the same time fill in the topography, using an ivory scale with a pro... tractor, to plot the angles and lay off the distances, using colored pencils to repres... the topography, and measuring the heights of the banks with a pocket-level. Wiebe... & Newton's improved solid sketch-book will be found very convenient for this pur... pose. The prismatic compass is not considered accurate enough for Lake-Survey pur... poses. In some instances, where the face of a country is open and concave, as on ... shores of bays, gulfs, &c., a very expeditious and accurate method of topograph... is by the use of a pocket-sextant, plotting the line of different angles to stations ... erected in the manner indicated under the head of "sounding."

A.—SOUNDING.

1. In very deep water (over 100 feet) the lead-line or one of the deep-sea apparatus may be used. The ordinary forms of such apparatus are as follows:

   First. The "rotometer" attached to a wheel like the propeller of a steamer whose revolutions it records. This should be used only in still water.

   Second. A heavy lead which is allowed to fall through the water with a light cord attached, not stout enough to recover it, but only to feel when it touches the bottom; the depth computed from the time of its fall.

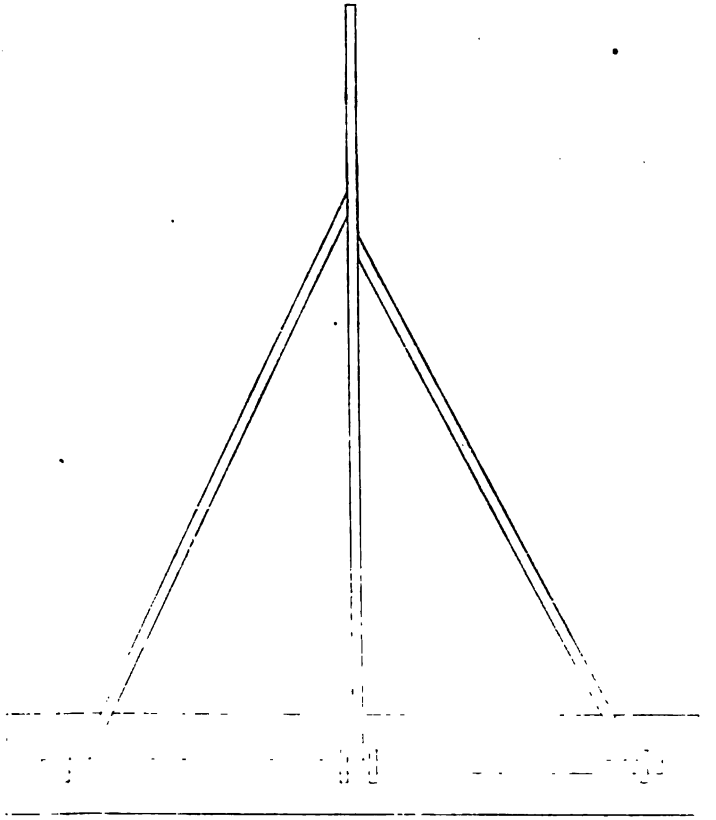
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Third. The "electric sounding-machine," invented by Mr. William P. Trowbridge, formerly of the Engineers.

Fourth. A very heavy weight, say 1,000 or 2,000 pounds, let down and recovered by a steel-wire rope and reeling-engine. This, the most ponderous of all apparatus, approximates in its turn to the ordinary and most simple method of the sounding-lead, and in very deep water, and with a strong current, the only one that should be relied on where accuracy is desired, as in determining routes for laying submarine cables over rough and dangerous places.

The small reels attached to the engine of the steamer devised for the steamers Search and Ada have given good satisfaction when applied to the first description of apparatus, and a similar device might perhaps be applied with advantage to haul in an ordinary lead-line, either in deep water or upon one of the small steamers.

If the water be between 30 and 100 feet, it is generally preferable to make use of the ordinary form of lead-line, but great care must be taken to have the weight of the lead proportioned to the depth of the water and the speed of the boat. Much unnecessary delay and expense have been caused by the neglect of this simple precaution. In less than 50 feet of water it is never necessary to run a steamer under check, and in deeper water, as soundings will not have to be taken very close together, the boat may be run at full speed during the intervals, and only checked down long enough to obtain the soundings. In water of an average depth of 50 feet, and with a lead weighing 16 pounds, perfectly plumb soundings were taken from a steamer while running at the rate of nine miles an hour; and if soundings cannot be taken thickly enough otherwise, two lines may be used alternately, one from either side of the steamer. Of course the man who throws the lead should stand well forward and as high as possible, and the lead should be picked up from near the stern of the boat.



Fifth. In water not more than 16 or 18 feet in depth, a pole may be substituted for the lead-line, if the current be very rapid, variable, and irregular, or if a very minute and accurate survey is desired. The most convenient lengths for these poles is to have one of 10 or 12 feet, and another of 16 or 18 feet.

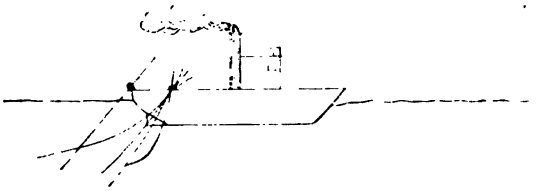
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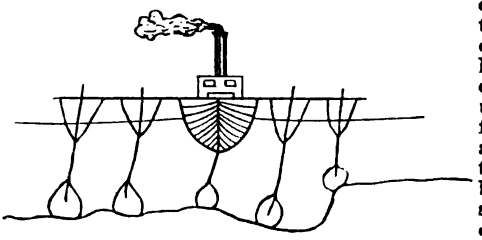
Second. In using a lead-line in shoal water the only precaution of importance is to record no soundings that are not plumb or nearly so. Sounding with the lead in rapids can only be effected by allowing the boat to drift with the current, and great care must be taken to keep the line free, for when the lead catches in the crevice of a rock, as is frequently the case, the line cut in the boat will frequently be endangered by a neglect of this precaution. (If the boat be moored to a scow, and held in the stream, the lead-line can be used, and soundings must be taken with a pole.)

Third. An automatic sounding-apparatus of the following form was constructed and used for sounding the rapids of the Saint Lawrence River during the last season.

A 3-inch iron rod "*a*," about thirty feet in length, was attached to the stern of a scow, and so held in position, by means of the chain "*b*," as to admit of no lateral motion independent of the scow, but moving freely in the vertical plane passing through its axis. The index "*c*" and the graduated scale "*d*," along which it moved, were of such size as to be conveniently read by means of the telescopes of the instruments on shore. A long anchor-chain also attached to her stern near the center served to keep the scow in position by dragging along the bottom. When, however, the water was of less depth than thirty feet this was more completely effected by the sounding-apparatus itself. A frame-work of iron, as shown below, would probably work better than chains to keep the rod in position.

A similar though lighter construction applied to the stern of a small steamer would probably reduce the labor and expense of sounding in shoal water to a very small fraction of that of the old method, and is strongly recommended for the trial. A self-recording apparatus attached to the shaft of the engine would also dispense with the inaccuracy and labor of recording in a note-book. A modification of this method for a minute harbor-survey, especially where excavation is made or contemplated, might be constructed as follows: A boom or mast is fixed athwart ships to the side of a tug to which several rods are attached as to the scow described above, and a vertical shaft attached to each rod at its pivot serves to communicate its angular motion to the recording-apparatus on board the boat, and thus a series of profiles is made simultaneously. It may often be desirable, either in this case or the simpler one, to have the iron rod furnished with a shoe of sheet-iron, and though this form is applicable in soft or muddy soil, it will not answer in the rapids. To show the rapidity with which soundings can be conducted by this method, let it be required, for example, to sound a river five miles in length, 300 feet wide, and from 20 to 30 feet in depth, (a fair average for the harbors on the Atlantic coast,) and let it be required to determine the depth at distances further apart horizontally than 10 feet. By means of five rods attached to a boom, a belt of 50 feet in width would be covered by this machine at once, and by passing back and forth three times the survey would be completed. This would require that the boat should travel thirty miles, which she would do in the space of five hours. By the old method $\frac{300 \times 5 \times 5280}{10 \times 10} = 79{,}200$ casts of the lead would be required, occupying 660 hours, if taken two in a minute, which would be very quick work for that depth. Where, however, a large area was to be covered it would be more economical to use a single rod, though not as satisfactory, from the difficulty of covering all the ground. In any of these automatic apparatus, the nature of the bottom is clearly indicated by the sound made by the rod in dragging over it, and should any doubt arise as to the bottom being muddy, sandy, or rocky, it can at once be set at rest by placing the hand gently upon the iron rod itself. In the apparatus employed on the Saint Lawrence, the sound could be distinctly heard on shore.





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B.—LOCATING SOUNDINGS.

In the matter of locating soundings the most desirable method depends upon the distance from shore, and the nature of the coast, the presence or absence of a current, &c., &c.

1. In taking soundings at a distance from shore extending out ten miles or more, as in off-shore hydrography on the lakes, the method of locating by two theodolites from shore, as practiced upon the survey, is sometimes as good as any other, and has this advantage, that when the steamer is out far from shore she can be readily distinguished by her smoke at times when it would be impossible from her deck to discern objects on shore. In this case, whenever it can be done, it is advisable to take one or more sextant-angles from the boat, at the time when the balloon falls, to serve as a check. If, however, the coast be high, and there are prominent objects, such as large buildings, light-houses, &c., which are readily distinguishable at a distance of eight or ten miles from shore, it will save much time and labor to use two sextants on board the ship, instead of stationary theodolites on shore.

2. If the distance from shore is less than five or six miles, it is almost always preferable to use two sextants on board ship. The advantages of this over the other method are:

First. It reqnires one assistant less.

Second. The time which is wasted in establishing observers on shore is saved, while, in rough weather, it is frequently impossible to land the observers at all.

Third. Any error from want of synchronism in the watches is obviated.

Fourth. And this latter is the most important consideration, the soundings by this method may be plotted as soon as they are taken.

There are three methods of plotting soundings by sextant-angles that may be employed according to circumstances.

First. The ordinary method by a station-pointer or three-armed protractor.

Second. By means of a graduated circle printed on tracing-paper.

Third. By the ordinary method of geometrical construction. By a modification of this method much time can be saved by plotting, upon a sheet of tracing cloth or paper, several systems of circles passing through each of the points upon the paper, taken two and two, which represent plotted positions of the stations most likely to be observed. It is convenient for this purpose to draw each system of circles in a separate color, and these circles may be so constructed that each is the locus of the vertices of all angles less by one degree than that next within it. The loci of angles of 5, 10, 15 degrees, &c., should be made rather darker or more prominent than the others, and the paper covered with circles, making good intersections with each other in this manner, before the sounding commences. Two or three angles are observed simultaneously with sextants at the time of sounding, and the position plotted by the eye by means of these auxiliary circles, and pricked through on to the sheet underneath. Of course those stations should be selected for observing whose circles will give good intersections, and it is well to take a third observation upon two other stations for a check, if facilities offer, or if the assistant is sufficiently skilled in the use of a sextant to enable him to take two observations before the boat has materially changed her position. A double sextant would enable one observer to take all the observations, superintend the sounding, and plot the position of the ship as rapidly as soundings could be taken. Should it ever become necessary for one assistant to take soundings in this manner, and if but a single sextant is at hand, he may proceed as follows: Observe the first angle and read it off. Then observe the second angle and read it, and take a third observation on the first angle, allowing an equal time to elapse in each case, making this time as short as possible. The mean between the first and third observations combined with the second, will determine the position with accuracy if the stations observed are not too near.

The great advantage of plotting the position of the soundings as soon as they are taken will be apparent when it is considered that by so doing the boat can be directed to any spot desirable, and should the steamer run off her course it will at once be detected and corrected. Where shoal water is found it is of course desirable to take soundings at much closer intervals than otherwise, and if the soundings are plotted as soon as taken, it will be seen at a glance where more sounding is required in order to show the nature of the bottom, and much superfluous work can be avoided. Indeed, whenever this method be practicable, none other should be tolerated, and assistants on the survey should all be familiarized with the use of the sextant and taught to regard it as pre-eminently the hydrographic instrument.

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3. Soundings taken near shore may be classified under the two following heads:

First. Shoal-water soundings on the lake-shore.

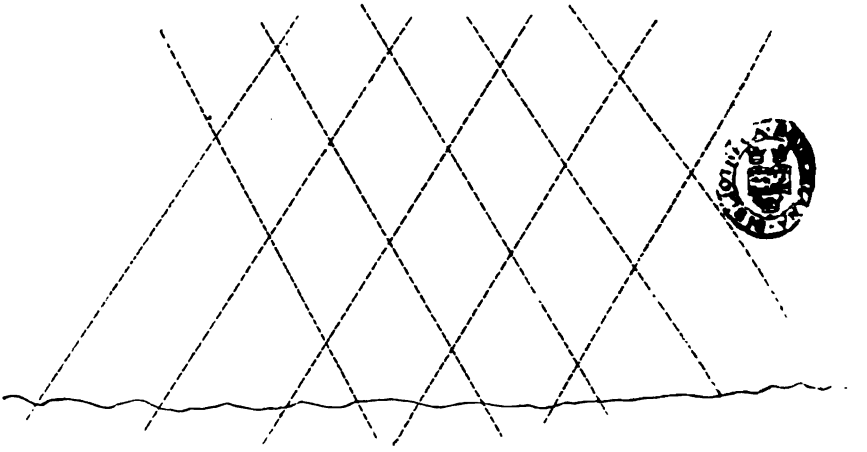
Second. Soundings in rivers and narrow bays, inlets, small lakes, &c.

In the latter case, if the body of water is wide enough, and the current not too rapid, the ordinary method by two sextant-angles will be preferable. The soundings in this case being taken from a steamer.

It will suffice to give a general description of the other methods of sounding with which all assistants in charge of parties should be thoroughly conversant, leaving it to their discretion which may be most economical in any particular instance.

First. A system of ranges may be established upon shore parallel to each other or nearly so, by means of small whitewashed stakes, one placed behind the other, distant from each other 50 feet or more. If any distant object can be seen from several of these stations in a direction perpendicular, or nearly so, to the shore, the stakes may be ranged upon this object, and much time will be saved which would otherwise be expended in locating these ranges. When these ranges have been set up, distant from each other from 100 feet to 200 feet, the boat is run along one of them out from shore and back again upon the next, and so on, taking a sextant-angle upon this range and some other object for a cut-off at the two extremities of the line and at as many points as may appear to be necessary or convenient, or the boat may run along upon any other course, say one parallel to the shore, and perpendicular to these ranges, and a sextant-angle taken with the range and some other object at the moment of crossing it. Instead of the back-range stake, a man stands at the sounding-stake may serve to keep the boat on the range by means of a flag, which he waves to the right or left, as a signal to the wheelsman who is running on the ranges.

Second. Another method is to establish a series of ranges intersecting each other upon the water, thus—



The boat in this case is run out upon one range and in upon another, soundings being taken on time, the time of passing the intermediate ranges indicated in the note-book. (This method is recommended more especially for use upon Lake Michigan, where from the open shore and the constant roughness of the weather during the summer season, small boats can only be used during a small portion of the time, and a large fraction of this time is, by the ordinary method, wasted in setting out the buoys.)

Of the above methods, one or more will usually be found more economical and complete than the ordinary practice of setting out buoys and sounding to and from them irregularly.

The necessity of having all the work of topography and hydrography plotted in the field cannot be too strongly urged. The old system of making a rough sketch of the lines of soundings is altogether insufficient. The soundings themselves show

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plotted, and so with *all* the work, and the chief of party will then be entirely at fault if any errors or omissions occur.

An extra recorder should be furnished to each shore-party for this purpose.

Very respectfully, your obedient servant,

W. R. LIVERMORE,
First Lieutenant Engineers, U. S. A.

Major C. B. COMSTOCK,
Corps of Engineers, U. S. A., Superintendent Lake Survey.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Michigan, December 11, 1871.

MAJOR: I have the honor to submit the following report of the work performed by the parties under my immediate orders during the season of field-operations of the current year:

I entered the field on the 21st of April, when I assumed command of the steamer Ada and reported to Lieutenant William R. Livermore, United States Engineers, for duty in Lake Saint Clair. Acting under his instructions, I built two primary triangulation stations, one 20-foot and one 35-foot center-post, after which I was engaged on general-service transportation of shore-parties, station-material, &c., until May 6, when I was transferred to the command of the steamer Surveyor. I then completed the off-shore hydrography of Lake Saint Clair, running eleven lines, varying in length from six to ten miles, built one 20-foot center-post station, and on the 10th of May returned to Detroit to fit out for the season's work in Lake Michigan.

I left Detroit in command of the Surveyor on the 15th of May, having on board the shore-party of Assistant Custer, and arrived at Grand Haven, Michigan, on the 20th of the same month, at which time, acting under your instructions, I assumed the "general charge of the surveys on the eastern shore of Lake Michigan."

From the 21st of May until the 7th of July my immediate party was engaged in reconnoitering for, locating, and building the primary stations necessary for carrying the azimuths along the shore, in setting up latitude-posts at each station, and in provisioning and moving the shore-parties of Assistants Foote and Custer.

On the 7th of July I went into camp at Frankfort, (Point Aux Becs Scies, or Point Betsey,) where I was to commence my astronomical work, placing Sub-Assistant Clark Olds in temporary command of the Surveyor, which command he retained until the 15th of August, when he was relieved by Lieutenant Charles F. Powell, United States Engineers.

Between the 7th of July and the 15th of August the crew of the Surveyor built ten sounding-stations and ran twenty-four lines of off-shore hydrography, besides provisioning and moving the shore and astronomical parties, which were five in number.

The lines referred to run east and west, were one mile apart, and averaged twelve casts of the lead, each being about ten miles in length.

Personally I occupied the stations Frankfort, (South Point Betsey,) Manistee, South Twin, (or Grand Haven,) stations for horizontal angle and latitude, the Big Point Sable station for horizontal angle, and the Little Point Sable and Duck Lake (White River) stations for latitude, for the details of which work you are respectfully referred to the annexed table.

The primary stations built by me are ten in number, varying in height of center-post from 10 to 55 feet, are all marked as per directions from the headquarters of the survey, and, as well as the sounding-stations, are all connected with the shore-line.

Primary stations built	13
Astronomical posts set	10
Angles read	4
Number of pointings	528
Number of vernier readings	3,168
Stations occupied for latitude	5
Number of pairs of stars	221
Miles of off-shore hydrography	322
Casts of lead	425

This work was all completed prior to the 28th September, at which time I moved my camp from the Duck Lake station to the Clay Bank station and the Surveyor returned to Detroit.

From the 28th of September to the 24th of October no work whatever was done, on account of bad weather, and I then returned to Detroit with my party.

The above table does not include the preliminary work necessary for the adjustment of the transit-instrument at the different stations, nor the observations for time, &c., necessary for getting the zenith-telescope into the meridian. Probably 50 per cent. of

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the tabular numbers should be added for these incidental readings. The work of connecting the stations with the shore-line, which is not included above either, was equivalent to about twenty miles of shore-line without the hydrography or topography.

The instruments used by me were the zenith-telescope No. 18, and the Oertling transit No. 2563. The first is an excellent instrument and was turned in by me in good adjustment. The transit is worthless, and in my opinion should be condemned.

I am, major, very respectfully, your obedient servant,

JNO. H. WEEDEN.
First Lieutenant Engineers, U. S. A.

Major C. B. COMSTOCK,
Corps of Engineers, U. S. A.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, December 27, 1871.

MAJOR: The following statement should be embodied in my report for the current year:

From the 7th of July until the 24th of October, a period of one hundred and nine days, during which I was engaged upon astronomical duty, there were eighty-five days on which I was prevented from working, either by day or night, by bad weather, leaving but twenty-four days for the moving of my camps and the performance of my work.

Very respectfully,

JNO. H. WEEDEN,
First Lieutenant Engineers, U. S. A.

Major C. B. COMSTOCK,
In charge of United States Lake Survey.

No. 76.] OFFICE UNITED STATES LAKE SURVEY.
Detroit, Michigan, December 13, 1871.

MAJOR: I have the honor to submit the following report of operations of the party under my charge during the season of 1871:

The duties with which I was immediately charged were the "off-shore hydrography on the west shore of Lake Michigan, the soundings across the lake, the geodetic determination of a point on Lake Michigan by connection with the main triangulation of Green Bay, or of Sturgeon Bay, and the determination, by a line of azimuths and latitudes starting from the point so determined, of the position of the main headlands from Sturgeon Bay to Milwaukee or other point where the triangulation from Green Bay reached the lake."

The shore-party of Assistant J. R. Mayer was also placed under my general supervision, and I was directed to supply them with provisions, move their camps, &c.

I left Detroit on May 14, in charge of the Lake-Survey steamer Ada, with Mr. F. Terry as assistant, and Messrs. J. A. Ockerman, D. C. Rexford, and F. M. Lee as recorders. These gentlemen, I may here add, were all new to the work. This being their first season on the Lake-Survey, I also took with me the shore-party of Mr. J. R. Mayer, and landed them on the west shore of Lake Michigan, about two miles north of the town of Port Washington, on the morning of May 18.

From the 20th to the 27th of May my party, including the steamer's crew, was engaged in reconnoitering for site for azimuth and sounding stations, building the same, and cutting lines of sight. Two azimuth and two sounding stations were built during this time. On May 29 and 31 some little work was done at off-shore hydrography.

On June 1 the steamer left Milwaukee for Sturgeon Bay. I found but two stations standing there (Sturgeon and Sherwood) that could be used.

The station known as North Sturgeon had been blown over, but as the place was accurately marked it was rebuilt over the original spot. This station and the one on the opposite side of the bay known as Sturgeon were used in the triangulation of Green Bay. The line connecting them I used as a base for my work. The sites for seven of the remaining stations were selected and the stations built by June 8. They were not occupied till later in the season.

The steamer left Sturgeon Bay for Lake Michigan June 8, and from that time till the end of the month we were occupied in selecting sites for stations, building the same, and running lines of off-shore hydrography. This work was also continued by the party on board the steamer during the month of July.

On the 23d of July I turned over the charge of the steamer to my assistant, Mr. Terry, and went into camp near the head of Sturgeon Bay to read the angles at the different stations. My party consisted of Mr. F. M. Lee, recorder, and four men. The instruments with which I was provided being totally unfit for this work, I was compelled to borrow a theodolite (Secretan No. 107, least count 20″) from Mr. W. T. Casgrain, who was engaged at the time making a survey under the direction of Major Houston, United States Engineers, for a canal from Sturgeon Bay to Lake Michigan.

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I finished reading the angles at the different stations August 4. The steamer arrived from Lake Michigan August 6, when I went aboard, met my party, and again took charge of her.

During the month of August work was continued on the off-shore hydrography and lines of sounding across the lake; also at building stations and cutting lines of sight.

The instruments which I was to use in my latitude and azimuth work arrived from Lake Superior on August 17. They were zenith telescope No. 1 (Würdemann) and Oertling theodolite No. 2562. The theodolite I changed, before using it, for one of the same make, No. 2563, which Lieutenant Weeden had in use on the east shore of Lake Michigan.

The zenith-telescope was in a filthy condition, but otherwise in fair order. Theodolite No. 2563 I did not have occasion to use, so can form no opinion of its merits or demerits.

On August 20 Mr. C. Olds reported to me with the steamer Powers for duty in connection with the triangulation from Green Bay to Lake Michigan.

Finding, after a careful reconnaissance of the country in the vicinity of Milwaukee and Racine, that it would be impossible to build the proposed line of stations between those points, and being in no further need of the Powers, Mr. Olds, according to your instruction, was sent to Detroit with her September 3, with orders to discharge her and her crew on arrival.

During the time spent by Mr. Olds in reconnoitering for station-sites, the crew of the Powers was engaged in building azimuth-stations between Milwaukee and Racine.

The high winds during the latter part of the month materially prevented much progress in our work.

During the month of September, and in fact up to the time of our leaving the field for Detroit, but little additional work was accomplished. The forest-fires and high winds prevalent during that time are assigned as sufficient reasons for this.

I regret that I have so little progress to report in my astronomical work. My instruments, however, did not arrive till August 17, after the best part of the season for this sort of work had passed.

I was not able to go into camp till September 15, and from that time till October 3, at which date I broke up camp, there was but one day suitable for the measurement of angles and but two nights in which I could observe for latitude.

The fires by the 2d of October getting uncomfortably close, I broke up camp and returned to Milwaukee with the steamer, where we were detained by the smoke and high winds till Sunday 15.

Between the 15th and 17th an azimuth-station was built at a point about five miles south of Sheboygan. On the evening of the 17th we left for Detroit, arriving, after a rough passage, on the 25th. I append hereto a tabular statement showing the total amount of work done during the season.

I am, major, very respectfully, your obedient servant,

A. N. LEE,
Lieutenant Engineers.

Major C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
Superintendent United States Lake Survey.

Number of sounding-stations built	8
Azimuth-stations built	7
Latitude-posts set	1
Latitude-stations occupied	1
Number of stations built in Sturgeon Bay	12
Number of stations occupied in Sturgeon Bay	21
Number of theodolite-readings in Sturgeon Bay	1,324
Number of miles of sounding	516
Number of miles of sounding along shore	50
Number of casts of lead	660
Number of lines across lake	3
Number of miles run by steamer	6,923
Number of days lost on account of bad weather	37
Number of lines of soundings	53

No. 101.] OFFICE UNITED STATES LAKE SURVEY,
Detroit, Michigan, June 29, 1872.

GENERAL: I have the honor to submit the following report on the work accomplished by the computing division since the date of the last annual report:

A check on all operations performed has been considered a necessity, and where an

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operation did not sufficiently prove its own accuracy the work has been done in duplicate. The work has been:

1st. *Longitude.*—The reduction of observations made at Detroit, Michigan, in connection with Battle Mountain and Austin, Nevada, and Duluth, Minnesota; of the observations made at Duluth, in connection with Detroit, and of the observations at Duluth, in connection with Saint Paul, making eleven time-determinations and twenty sets of clock or chronometer comparisons. These observations were from the chronographic record.

The reduction of two nights' eye-and-ear observations at Saint Paul, in connection with Duluth. The reduction of two remaining nights' observations from chronographic record at Duluth, in connection with station East Sawteeth Mountains, and of three nights' eye-and-ear observations at East Sawteeth Mountains, where powder-flashes were used as signals in comparing chronometers, and also the reduction of three nights' eye-and-ear observations at each of the stations, Vulcan, near Copper Harbor, and Thone's Hill, near Marquette, Michigan, where powder-signals were used in comparing chronometers.

The reductions for time have been made independently by two computers and by two different methods; the one by high and low stars, the other by the method of least squares.

2d. *Personal equation.*—The reduction of observations between yourself and Assistant Wisner on three nights; between yourself and Assistant Flint on two nights; between yourself and myself on seven nights, and between Assistant Wisner and myself on two nights, the observations being from the chronographic record.

3d. *Latitude.*—The reduction of observations at four stations on Lake Michigan, to check a former computation by Lieutenant Weeden.

4th. *Triangulation.*—The computation of the base-line on Lake Saint Clair and the triangulation of Lake Saint Clair.

The computation of the geodetic positions of twenty-five triangulation stations on Lake Saint Clair, of twelve stations at the west end of Lake Superior, and three stations on the south shore of Lake Superior. The computation of thirteen triangles on Sturgeon Bay, Wisconsin, and the transferring of the geodetic latitude and longitude from Green Bay to a point on Lake Michigan near Sturgeon Bay.

5th. *Co-ordinates.*—The referring of thirty-six triangulation and shore-line stations on Lake Saint Clair to 5-minute meridians and parallels, and of fifty-five such stations at the west end and south shore of Lake Superior to 30-minute meridians and parallels.

6th. *Correcting of shore-line.*—The searching out of errors in the computations and mapping of about fifty miles of shore-line found to exist by comparing with primary triangulation, requiring the re-reducing and remapping of about thirty miles of the shore-line, and the making of a new chart to take the place of the old for a distance of twenty miles.

7th. *Water-levels and tidal curves.*—The reading off and reducing of the self-registering water-gauge for 1871 for Milwaukee and Superior City, Wisconsin, for solar hours and the re-reading and reducing of an unbroken five months' curve at Milwaukee, in 1867, both for lunar and solar hours, and the plotting of the monthly lunar curves and their mean curve, and also of solar curves, for each of five years and their mean curve. The computing of co-ordinates from five daily means for the conjunctions, oppositions, and quadratures of the sun and moon for the years 1867 and 1868 at Milwaukee, and the plotting of curves from these co-ordinates. The reducing of staff-gauge readings at each of eight stations.

8th. *Meteorology.*—The reduction of the observations for ten stations.

9th. *Miscellaneous.*—The tabulating and putting in form the results from all computations. The comparing of a finished reduced chart with the original data. Observing for time and rating of twenty-one chronometers, usually at intervals of ten days, preparing a corrected list of latitudes and longitudes of all points determined, either astronomically or geodetically, by the Lake Survey. The reducing of eleven sets of magnetic observations for determining the moment of inertia of the ring and stirrup. Observing for and reducing two sets of observations for determining the value of the micrometer-screw in zenith-telescope No. 18. Furnishing data whenever called upon to assistants in other departments of the survey, and to others when directed so to do. The reducing of the connections of primary-triangulation stations built in 1871, with shore-line station and recording the same with a description of the stations.

I have been assisted in this department by Sub-Assistants Thomas Russell, William A. Metcalf, C. H. Kummell, and John Eisenmann.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Lake Survey.

Brevet Brigadier-General C. B. COMSTOCK,
Major of Engineers, United States Army.

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No. 77.] OFFICE UNITED STATES LAKE SURVEY,
December 14, 1871.

SIR: I have the honor to submit the following report of field-work performed by the party under my charge during the past season:

In compliance with your instructions, I left the office May 1, for Lake Saint Clair, to measure the angles for the triangulation of the lake in connection with Assistant A. R. Flint. Owing to an unusual amount of stormy and unfavorable weather the work was prolonged until May 18 before being completed. (For summation of work see table at close of report.)

1st. On May 22 I left for Lake Superior, on steamer Search, with Assistants A. R. Flint and G. A. Marr's parties on board.

At Iroquois Point, Lake Superior, we were detained a couple of days connecting the shore-line of the point and island with the triangulation and checking of the azimuth of Rose's Island.

On May 27 arrived at Porcupine Mountains and commenced operations for connecting station with shore and correcting discrepancies that had been found in the previous shore-line work between that place and Bayfield. In the valley of Carp River a base-line was measured, from which the triangulation was carried to the front range of hills and thence to lake and back to station on the mountain. Owing to the very smoky weather we were unable to obtain any azimuth-checks on the shore-line from Porcupine Mountains, and consequently were obliged to work it back by shorter lines from Bayfield. Taking the line *Bayfield—Michigan Island Light-House* as a base the triangles *Bayfield—Michigan Island Light-House—Little Girl's Point* and *Michigan Island Light-House—Little Girl's Point—Presq'ile River* were measured, thus dividing the distance into three nearly equal distances. The old stations of the shore-line work having been all destroyed, making it necessary to run the shore-line anew in order to carry the work any farther east, and the weather setting in foggy and stormy, it was found necessary to leave the work at this place and proceed to Duluth to have arrangements for longitude-work at North Base in readiness on your arrival there. Leaving a party on the way at the Clay Banks station to cut lines, we arrived at North Base June 4, Assistant Flint proceeding at once to Saint Paul to make arrangements for longitude-observations at that place, in connection with Duluth and Detroit. On your arrival at North Base, June 8, Assistant Marr proceeded to Burlington Bay with steamer to reconnoiter for a suitable place for a station, having found which, he went into camp at Sawteeth Mountains, to observe for longitude, in connection with Duluth, leaving the steamer and crew in charge of Assistant Metcalf, to finish building the station at Burlington. From June 8 to June 24 the work of making longitude-connections with Detroit and Saint Paul was under your immediate supervision, and consequently you are already aware of the extra labor and loss of time that arose from poor telegraphic connections and broken lines.

During this time one night's exchange of clock-signals was obtained with Detroit and two with Saint Paul, and also three nights' observations of powder-flashes, in connection with Assistant Marr at Sawteeth Mountains, which place had already been connected with Vulcan by the same means. Vulcan, at a later period in the season, was connected with Marquette, the longitude of which place had previously been determined by telegraphic connection with Detroit.

After your departure operations were continued until two more nights' exchange of signals was obtained with Detroit and the necessary observations for latitude and azimuth made at North and South Bases.

Of the great amount of extra labor and loss of time arising from the dificulty in getting clock-signals through to Detroit, it will be sufficient to say that thirty-one nights' observations were made before the necessary exchanges were obtained.

Having finished the measurement of the angles of the triangulation at North Base, South Base, Middle Base, Superior, and Oneata, I moved my camp, July 17, to Amimcon River, and continued my observations for latitude-azimuth, and measurement of angles. Assistant A. R. Flint, on finishing his observations at Saint Paul, returned to the Clay Bank station, and placing a division of his party in charge of Mr. J. C. Jones, to work in connection with himself and Assistant Marr, proceeded to measure the angles for carrying the triangulation westward from the line Detour Split Rock, where the work was discontinued the previous season, and to connect with my observations at the base-line and Amimcon River. In measuring the angles on the short lines near the base considerable time was spent in waiting for weather suitable for making observations. Owing to the fact of lines passing either near water or land, the lines of sight were through a stratum of atmosphere continually disturbed by the reflected heat of the sun; but in making azimuth-observations it was found that by an hour after sunset this disturbed state of the atmosphere almost entirely ceased to exist. I would, therefore, respectfully suggest that, in triangles with sides of less than twenty miles, the experiment be tried of measuring the angles at night to lights on the other stations, as I am confident that by this means angles can be measured in a few hours, and with much less range of results, which, with the ordinary weather of the summer

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season, might require a week or more of waiting to obtain suitable weather for w[illegible] the daytime.

During the time the triangulation parties were engaged with the measurement [illegible] the steamer, under the direction of Assistant Metcalf, was kept employed in re[illegible] and building stations, cutting lines, and moving parties.

On the 30th, the triangulation of the west end of the lake being completed, the p[illegible] were picked up, and on the following day a line of soundings was run from a [illegible] some twenty miles east of Bayfield to the north shore, near Mount Josephine.

A flashing party was then landed at East Isle Royale station, and after sound[illegible] line back to Ontonogon, the steamer proceeded to Copper Harbor, where my part[illegible] into camp near Vulcan station. Assistant Flint and recorder were left at Whe[illegible] to remeasure the angles at that station, and the remainder of his party sent to H[illegible] Mountains to flash. The steamer then proceeded to Marquette to coal and met P[illegible] fessor Smith, the zoologist. Under direction of Assistant Marr some sounding[illegible] dredgings were then made, and the parties landed at Michipicoten Island, Tip Top[illegible] Saint Ignace, the details of which will be found in his report.

The parties were thus distributed with the idea that most of the errors of the [illegible] vious measurements, which it was the object of the present work to correct, had [illegible] made at the Vulcan station; but on the measurement of the angle Tip-Top-V[illegible] Saint Ignance, it was found that such was not the case, and consequently o[illegible] arrival, August 23, it was decided that Assistant Flint should take charge of the m[illegible] ments at Vulcan, while I proceeded to Tip-Top to remeasure the angles at that s[illegible]

From August 23 until September 13, the work was carried under your imm[illegible] supervision and the errors of the former measurements corrected.

The steamer in the mean time, under the direction of Assistant Metcalf and Pr[illegible] Smith, was engaged, whenever other duties permitted, in making soundings [illegible] dredgings in different parts of the lake.

On September 7 I returned to Vulcan station from Tip-Top, and Assistan[illegible] moved to Marquette to make observations for longitude, in connection with [illegible] Vulcan. Owing to the dense smoke that settled in from the heavy fires in M[illegible] and Wisconsin, this work was not completed till September 21.

In connection with Assistants Flint and Marr I then proceeded to the measur[illegible] of angles and the determining of azimuth for the triangulation in Keweenaw B[illegible] Here we also encountered a great deal of stormy and smoky weather, but finall[illegible] ceeded in completing operations October 18.

Taken as a whole the season has been more than usually stormy, and in the [illegible] part of the season the delays caused by the heavy storms and dense smoke more [illegible] doubled the necessary labor for completing operations.

It is with pleasure that I refer to the hearty co-operation of all the parties a[illegible] general interest exhibited in the advancement of the work. The general health [illegible] has been excellent, and no serious illness or accidents have occurred.

Provisions furnished during the season have, with but few exceptions, bee[illegible] superior quality, but, owing to the division of parties and the necessary employm[illegible] inexperienced cooks, considerable waste and breakage have occurred which other[illegible] would not have happened. Considerable inconvenience was also found in making a fit-out for the flashing parties. As but few of the cooking-utensils had been dupl[illegible] for that purpose, it necessarily rendered the supply of all a little deficient. The Ir[illegible] ton and Simms theodolite used by me during the past season is, as far as gradu[illegible] and practical working are concerned, a first-class instrument. I have, however, [illegible] defect to mention. The wyes are non-adjustable and one longer than the other, m[illegible] ing it necessary to make a level correction whenever the objects sighted at are [illegible] the horizon of the station occupied. This might, however, be corrected somewh[illegible] having the longer ground down.

The portable transit No. 15 has had a portion of the wires broken out of th[illegible] phragm and replaced by others of unequal size and appearance. I would respe[illegible] suggest that an entire new set be put in, as it would be a decided improvement [illegible] instrument.

Zenith-telescope No. 12 is in good working order with exception of striding [illegible] which needs refilling.

Summary of season's work.

LAKE SAINT CLAIR.

Number of stations occupied	[illegible]
Number of angles measured	[illegible]
Number of pointings, repeating theodolite	[illegible]

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LAKE SUPERIOR.

Number of triangulation stations occupied	12
Number of angles measured	43
Number of pointings with non-repeating theodolite	2,168
Number of pointings with repeating theodolite	315
Number of stations occupied for latitude	3
Number of stars observed for latitude	423
Number of stations occupied for longitude	2
Number of stars observed for longitude	773
Number of stations occupied for azimuth	3
Number of observations for azimuth	162
Number of miles of sounding run by steamer	330
Number of stations built by steamer's crew	7

Very respectfully submitted.

GEO. Y. WISNER,
Assistant Lake Survey.

Brevet Brigadier-General C. B. COMSTOCK,
Major Corps of Engineers, United States Army.

No. 79.] OFFICE UNITED STATES LAKE SURVEY,
Detroit, December 15, 1871.

SIR: I have the honor to submit the following report of field work, during the season of 1871, from May 1 to October 23.

From the 1st till the 20th of May I was engaged on the triangulation of Lake Saint Clair, in connection with Assistant G. Y. Wisner. Owing to the stormy and hazy weather that prevailed during a part of the time, the work was protracted longer than it otherwise would have been. Much difficulty was experienced at the three stations located along the line of the Great Western Railway of Canada, on account of the lines of sight passing through long cuts in the woods and in close proximity to buildings, trees, and other objects.

The smoke and steam from passing trains also caused temporary interruptions. The atmosphere was in such an unsteady condition that it was usually late in the afternoon before objects became sufficiently distinct and steady to observe upon. No such difficulty occurred at other stations.

I was furnished transportation by the steamers Search and Surveyor, at such times as would interfere as little as possible with their other duties. A summary of the work performed will be found annexed to this report.

On the 23d of May I started for Lake Superior, with a party consisting of two recorders and five men, on board of the steamer Search, under charge of Assistant G. Y. Wisner. After arriving at Lake Superior, I was engaged on secondary triangulation and shore-line duty, until the 6th of June, under the immediate direction of Assistant Wisner. The details of the work during this time will be embraced in his report.

On the 6th of June I was landed at Duluth, and proceeded to Saint Paul, Minnesota, for the purpose of determining the latitude and longitude at that point. The observatory was located on the court-house square, near the corner of Fourth and Cedar streets, and was connected by telegraph-wires with the office of the Northwestern Telegraph Company, thereby giving direct communication with the Lake-Survey observatories at Duluth and Detroit. The observations for latitude were made with the Würdemann zenith-telescope No. 1, and extended over four nights. The observations for time were made with a 32-inch Würdemann transit and sidereal chronometer by eye and ear. The chronometer was compared with the sidereal clock at Duluth in the following manner:

First, coincident beats of mean and sidereal-time chronometers were observed and recorded, and then coincident beats of clock and mean-time chronometer were recorded.

Secondly, signals were recorded on the chronograph at Duluth, as nearly coincident with chronometer-beats as possible, with both mean and sidereal chronometers. Afterward the chronometers were again compared, as at first.

In observing coincident beats of clock and chronometer by means of an ordinary relay, it is desirable to avoid the "double tick" of the armature, as it requires close scrutiny to determine whether the coincidence is observed when the circuit is broken or closed.

By placing a piece of wood between the coils of the relay, in such a manner as to prevent the armature from striking any metal when the circuit was closed, the sound was almost completely destroyed. By this means a sharp tick was obtained when the circuit was broken, by the clock, and the coincidence was as readily observed as in comparing two chronometers.

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The observations for time were taken on two different nights, the atmosphere being very clear and steady. The observatory post was referred to the cupola of the court-house, the southwest corner of the county jail, the southeast corner of the new custom-house, and to the northeast corner of the American Express Company's buildings.

On the 19th of June I returned to Duluth, where I was engaged two nights in observing for personal equation with yourself. On the 22d I joined my party at Clay Banks, where it had been engaged, during my absence at Saint Paul, in cutting out lines of sight and flashing powder signals, under direction of Mr. J. G. Pattengill. From this time till the 10th of September I was engaged on general triangulation duty on Lake Superior, occupying, during the time, stations Clay Bank, Buchanan, Wheal Kate, and Vulcan. In the latter part of June my first recorder, Mr. J. C. Jones, was detailed to measure angles of the triangulation until the work was completed in the west end of the lake. He was provided with camp-equipage, stores, and men from my party, and with one of the Oertling theodolites from the steamer Search. Mr. Jones occupied and completed the observations at stations Detour, Burlington, and Lester River, also connecting those stations with shore-line stations. Considering his comparative inexperience and the poor instrument furnished him, I think Mr. Jones's results are entitled to favorable consideration. He rejoined my party about the 1st of August.

About the 5th of August my party was divided into two sections and detailed for heliotrope duty, one section being located at Tip-Top, under charge of Mr. Pattengill, and the other at Huron Mountains, under charge of the observatory attendant. About September 25 the party was again united and remained on heliotrope duty at Huron Mountains, under direction of Mr. Pattengill, until the close of the season.

At Wheal Kate, the angle between Isle Royale and Vulcan was not as well measured as was desirable, on account of the very poor light sent from Isle Royale. The results obtained are probably only approximate, as the atmosphere was not very steady during the time they were obtained.

From August 24 to September 7 I was placed in charge of Assistant Wisner's party while he he was absent making observations at Tip-Top. During this time angles were observed at Vulcan between Isle Royale and Saint Ignace, and between Tip-Top and Michipicoton Island.

On the 8th of September I proceeded to Marquette for the purpose of determining the difference of longitude between stations at Thone's Hill and Vulcan, Assistant Wisner observing at the latter point. Observations were obtained on three nights, and chronometers compared by means of powder-flashes. The weather during this time was extremely unfavorable for exchanging signals, the atmosphere being filled with fog and smoke nearly all the time.

I remained at this station fourteen days before three clear nights were obtained on which signals could be seen from Vulcan. After leaving Marquette I proceeded to Huron Mountains, where I remained one week, completing the observations for triangulation at that point. During the remainder of the season I was on board the steamer Search, Assistant Wisner in charge, engaged on the triangulation of Keweenaw Bay.

During the season observations were made for latitude of Buchanan and south base, Keweenaw Point, and were referred to the respective stations.

The theodolite used in triangulation was the 10-inch Gambey circle, except at Huron Mountains, where the new Troughton and Simms theodolite was used. Both instruments gave good satisfaction.

On the 23d of October I arrived at Detroit on board the steamer Search, and the party was discharged on the 24th.

The amount of work accomplished during the season will be found annexed in a condensed form.

I desire to express my obligations to Messrs. Jones and Pattengill for their hearty co-operation and assistance at all times, and for the faithful and intelligent discharge of all duties intrusted to them.

Respectfully submitted.

A. R. FLINT.
Assistant Lake Survey.

General C. B. COMSTOCK,
Superintendent United States Lake Survey.

The following is a condensed summary of the amount of work performed by the party under charge of A. R. Flint, during the season of 1871.

Triangulation of Lake Saint Clair.

Number of stations occupied	9
Number of angles measured	35
Number of repetitions of angles	1,112
Number of single pointings	10[illegible]

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Triangulation of Lake Superior.

Number of stations occupied	8
Number of angles measured	40
Number of repetitions	4,720
Number of single pointings with Troughton and Simms's theodolite	467
By J. C. Jones, with Oertling theodolite	393
By J. C. Jones, number of stations occupied	3
By J. C. Jones, number of angles measured	10

Longitude-work at Saint Paul, Minnesota.

Number of nights observed	3
Number of stars observed for time	79

Longitude-work at Thone's Hill.

Number of nights observed	11
Number of stars observed for time	152
Number of powder-signals observed	60

Latitude-work at Saint Paul, Minnesota.

Number of nights observed	4
Number of stars observed	278

Latitude-work at Buchanan.

Number of nights observed	4
Number of stars observed	238
Number of obstructions on Polaris to determine value of micrometer-screw	78
Number of comparisons of level and micrometer-screw	16

Latitude-work at south base, Keweenaw Point.

Number of nights observed	4
Number of stars observed	156

RECAPITULATION.

Number of stations occupied	20
Number of angles measured	83
Number of repetitions, Gambey theodolite	5,832
Number of single pointings, Troughton and Simms and Oertling's theodolites	800
Number of stars observed for time	231
Number of stars observed for latitude	672
Number of nights observed for time	14
Number of nights observed for latitude	11
Number of flashes observed	60

No. 81.] OFFICE UNITED STATES LAKE SURVEY,
Detroit, December 16, 1871.

DEAR SIR: I have the honor to make the following report of field work accomplished in connection with the party under my charge during the season of 1871.

I left Detroit on board United States steamer Search May 22, for duty on Lake Superior, the party consisting of two recorders and three men, with the Assistant in charge. Was on board the steamer until June 13, under the orders of Assistant G. Y. Wisner, until his party landed at Duluth, June 8, then had charge of the steamer, to locate and build the station next west from Split Rock. This station was 75 feet high, with a 50-foot center-post. Went into camp at Sawteeth Mountains June 13, for the purpose of taking observations for longitude, connecting with Duluth by means of powder-flashes. This work was finished June 21. Went into camp at Split Rock June 22, when the regular work of the main triangulation was commenced.

The new instrument, theodolite No. 2, Pistor & Martin's, Berlin, made expressly for the Lake Survey, was received at this time. Reference will again be made to this instrument.

Finished the work at Split Rock July 8 and went into camp at Brulé River

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July 9. At this station, besides the work of main triangulation, a post was put ... observations taken for latitude. The work at the west end of the lake being ... July 30, the party was taken on board the steamer Search, and was again under ... orders of Assistant G. Y. Wisner, in taking soundings, &c., until August 7, when I was left in charge of the steamer to land flashing parties at Michipicoton Island and Tip-Top, and also to run lines of sounding so far as practicable without delay in landing the parties. A line of sounding was run from near Laughing-Fish Point to near the west end of Michipicoton Island. Professor S. I. Smith, the zoologist, was taken on board the Search August 4, and while the above line of soundings was being run several attempts at dredging were made, but were not successful, as there was a heavy sea at the time. The flashing party, consisting of Mr. Iddings and one man, was landed at Michipicoton Island August 9, and Mr. Pattengill and three men were landed at Simmon's Harbor for Tip-Top station the same day.

While in this habor dredgings were taken with good success. Left Simmon's Harbor August 11, and when about five miles out on line toward Isle Saint Ignace Professor Smith made another successful dredging. Arrived at Isle Saint Ignace on the morning of August 12, and the steamer left the Island August 13. Worked at the main triangulation until August 27, when you arrived and had charge of the work until September 13, during which time the observations on main triangulation were continued and observations taken for latitude, both on the north and south shores of the island, Sub-Assistant W. A. Metcalf aiding in the latitude work; and also a base-line 487 feet was measured and a secondary triangulation completed, so as to connect the latitude posts with the main station.

Mr. Metcalf observed most of the angles in this part of the work. The eccentricity of the horizontal circle of theodolite No. 2 was carefully determined by yourself. Weather very foggy, and unfavorable for main triangulation work while at this camp.

Left Isle Saint Ignace on board steamer Search September 12, and went into camp again near Portage Entry light-house, to take observations for main triangulation at Crebassa Station; and also observations for latitude were taken near the light-house.

The weather was very smoky and unfavorable during the rest of the season. We went into camp at Traverse Point October 10, and finished the observations for main triangulation at this station October 17, and was taken on board steamer Search. A party of my camp had been left at Crebassa Station, and was taken on board October 20, which ended the season's work, so far as my party was concerned, with the following amount of work accomplished:

Main triangulation.

Stations occupied	5
Theodolite pointings, non-repeating instrument	3,...
Theodolite readings, non-repeating instrument	3,...
Theodolite pointings, repeating instrument	22...
Theodolite readings, repeating instrument	19...
Angles measured	7

Secondary triangulation.

Stations occupied	7
Theodolite pointings, repeating instrument	1,...
Theodolite readings, repeating instrument	1,...
Theodolite pointings, non-repeating instrument	8...
Theodolite readings, non-repeating instrument	12...
Angles measured	12...
Stars observed for longitude	2...
Powder-flashes observed for longitude	2...
Stations occupied for longitude	1
Stars observed for latitude	1,...
Stations occupied for latitude	4
Chaining, feet	1,...
Primary stations built	5
Secondary stations built	7
Latitude posts built	4
Vertical angles measured	5...

The theodolite No. 2, Pistor & Martin's, Berlin, seems to have been made with great care, and the graduated circles and the micrometers were excellent; but there were several faults that led to much inconvenience. The arrangement of the eye-piece tube, by which a change of focus could be effected, was such as to invariably change the adjustment for verticality of cross-wires at every change of focus, as the adjusting screws had to be loosened in order to slide the eye-piece tube.

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This difficulty can be obviated by using two pieces of steel about 1½ inches in length and $\frac{1}{16}$ of an inch thick, and made to fit one on each side of the guiding-bar of the eye-piece tube, and against which the points of the adjusting-screws should rest.

This can be fixed without much expense. The cross-wires were all too coarse, and the line of collimation being the narrow space between two of these coarse wires, made it very indistinct and uncertain in sighting to any other signal than a flash. In the Keweenaw Bay work, where most of the signals were either stations or targets, it was found necessary to remove one of the vertical and collimate on the other.

This worked much better, but the wire was too coarse. The diaphragm could not be removed in the field, or finer wires would have been substituted. I would suggest in replacing the cross-wires that there be fine vertical wires, only one in the center and two horizontal wires, as at present.

The principle on which the clamp to the horizontal circle is constructed, is not a good one. The clamping is effected by merely pressing a small piece of steel about one-half an inch in length, by one-third inch in width, against the vertical axis, and of course only on one side. This invariably tends to throw the plane of the micrometers out of center, causing an increase of eccentricity, and especially if there is play enough given to the instrument on the vertical axis to allow of free and easy motion. This may not affect the final results of the angles very materially, as the two micrometers will in a measure eliminate the error arising from eccentricity. During the warm weather of summer the instrument can be adjusted so as to nearly obviate this variable eccentricity; but during the quite cold weather, while working in Keweenaw Bay, this adjustment was quite impossible. This defect cannot well be remedied without an entire change of clamp.

At Brulé River station there was found to be a very marked twist to the center post in one direction during the heat of the day, and then a return during the night. Many observations were taken while at this station, both during the day and at night, in order to determine the rate of twist, and at what time the maximum and minimum occured.

During a day of uniform sunshine and clear atmosphere, this twist seemed to be quite regular, and at the rate of about *one second* of arc per minute of time, reaching a maximum about 7 p. m., and a minimum about 7 a. m., during the month of July. On partially cloudy days there was no regularity in the twist, being sometimes in one direction, and again in the opposite.

The twist of a center post does not seem to depend with any certainty upon its height or form, as a much higher station of the same form as this at Brulé River did not seem to have any very perceptible twist. While the twist of the post at night is about as great as during the day, yet it seems to be much more uniform. Great care should always be exercised in taking observations, so that any errors that may arise from twist of posts shall be eliminated. As to signals used in main triangulation the flash from a mirror or heliotrope properly tended seems to be the most reliable one at present.

The ordinary pyramid station is too much subject to phase, and targets at a greater distance than ten or fifteen miles are too indistinct. As the air is less liable to be affected by changes of temperature during the night, it is probable that excellent results might be obtained by having lanterns properly constructed with reflectors so as to give a strong light, as there would probably be a time of three or four hours' duration during the night when the conditions would be quite favorable. The micrometers on the theodolite No. 2 can be read just as well at night as during the day.

The greatest care should be used in flashing to stations, to see that mirrors and screens are well on range, and the aperture in the screen such as to give a small and well defined light, the aperture larger or smaller according to the distance from the station flashed to. And it would be well to have screens so arranged that the apertures could be made smaller or larger according as the sun was in the direction of the station flashed to, or on the opposite side; and also that the change could be effected without change of range.

There are several ways by which this could be accomplished. An excellent one would be to have the aperture arranged on the same principle as that of the illuminating-lamp to the larger astronomical transit of the Lake Survey. But a simple means would be to have several square pieces of tin of the same size with circular apertures of different sizes exactly in their centers—these to be attached to the screens so as to be easily removed or exchanged.

The line of sight from Split Rock to Burlington passed over, and very near to, the trees on a point about three miles distant from Split Rock; and the flash was so affected by lateral refraction during the heat of the day that it was impossible to get good results.

The same difficulty was experienced on the line from Crebassa station to Traver's Point, the line of sight in this case passing through a cut on a point about two or three miles from Crebassa station; and passed much nearer one edge of the cut and but very little above the bottom.

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In such cases the observations should be taken only during the most favorable weather and conditions of the atmosphere. I beg leave also to make special mention of the valuable assistance always promptly given by my recorders, Messrs L. M. [illegible] and V. M. Spalding.

All of which is respectfully submitted by your obedient servant,

G. A. MARR,
Assistant United States Lake Survey.

General C. B. COMSTOCK,
Major Corps of Engineers.

No. 100.] OFFICE UNITED STATES LAKE SURVEY.
Detroit, Michigan, June 14, 18[illegible]

MAJOR: I have the honor to report the following field operations of the shore-party under my charge, on the east shore of Lake Michigan, from May 15 to October 4, 18[illegible].

Left Detroit on the evening of May 15 per Detroit and Milwaukee Railroad to [illegible] Haven, thence by boat to White Lake, where we arrived at our first camp on the [illegible] noon of the following day, having camp in order and ready for work on the morning of the 18th.

Our work at this camp consisted of a survey of the shore of Lake Michigan northward to and connecting with the work of Lieutenant W. R. Livermore of the previous season, a distance of about eight miles; to continue the same southward about one-half way to the entrance of Muskegon Lake, or about six miles; to make a survey of the whole of White Lake, which is five miles in length and varying from one-half to one mile in width. The work included shore-line topography, triangulation and sounding.

The soundings in Lake Michigan extended to a distance of at least one-half mile (from shore,) and to a depth of not less than five fathoms. The soundings in White Lake required a row of buoys for nearly two-thirds its length.

The triangulation of White Lake contained sixteen triangles, the length of the base-line being 691.799 meters.

June 12, the steam-launch Meade arrived at camp, but not in time to be of any use.

June 15, moved camp per United States steamer Surveyor to Muskegon Lake. From here we continued the survey of Lake Michigan to a point about five miles northward of Grand River, a distance of ten miles; also made a survey of Muskegon and Bass Lakes.

The former is about five miles in length, and from one to two miles in width. The latter about four miles south of the former, being very narrow and five miles long: can be entered by only the smallest craft, drawing not more than four feet.

The Muskegon Lake triangulation contained twelve triangles, the length of the base 857.13 meters.

July 11, we changed our camp to Grand River. The distance being only about eleven miles and a good harbor for us about half way, we moved with our own boats, making three trips, loading the row-boats and towing them with the steam-launch.

Here we ran the shore-line northward, connecting with that from our last camp, about five miles, and southward more than ten miles to Pigeon River, which is about half the distance to Black Lake, where our next camp was to be. Here, too, we made a survey of Spring Lake, a beautiful sheet of water, about one-half mile in width and five miles in length, and nearly in the shape of the letter S. At the head of the lake is situated the new village of Fruitport. We also made a survey of Grand River, three miles, to the entrance to Spring Lake.

July 31, moved camp to Black Lake, (near Holland,) per steamer Surveyor. From here we carried the survey northward to Pigeon River ten miles, and southward seven miles, to connect with Assistant Custer's work, about a mile and a half north of the Kalamazoo River.

Black Lake is five miles long, and varying in width from one-third to two miles, and very irregular. Its triangulation required twenty-eight triangles. At this place the base-line was 431.565 meters long.

August 16, Sub-assistant C. F. Harrington was compelled to leave the party on account of sickness, from which he never recovered.

August 20, Sub-assistant W. C. Sauer joined the party.

August 25, the party was transferred to Michigan City, at the south end of the lake, by the steamer Surveyor, with instructions not to work to the eastward. At this camp we made a survey of the Lake Michigan coast to the southwestward twelve miles; much of the time it being very stormy. At Michigan City we ran one station eight miles back from the shore, to obtain a section of the old beaches referred to in your instructions of August 4, 1871, a profile of which will be found on the map of this portion of our work. Owing to sickness and the delays resulting therefrom we did not get other sections, which I very much regret.

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September 12, moved camp, per a hired tug, to the Grand Calumet River. There we had no harbor for the steam-launch, and were obliged to haul her upon the beach, where she remained the remainder of the season. From this camp we continued the survey to a point three miles west of the Grand Calumet, making twenty-three miles from Michigan City.

At the south end of the lake we found sand-dunes, in most cases covered with trees, extending from one-half mile to a mile and upward back from shore, back of which, and extending all along the south end of the lake, is a marsh but little higher than the level of the lake. These dunes being so very irregular and uneven and timbered, made the topography very difficult to obtain, so that it kept one-half the party employed all the time, and the rest during stormy weather to keep pace with the shore-line and soundings; in fact, with this amount of work, the topography was about three miles behind at the close of the season.

I am not at all satisfied with the character of the bottom, as represented in this portion of the lake. In only one case to my knowledge, (and that one gravel,) did the greased lead give anything but sand, excepting where dredging was going on in the harbor of Michigan City; but I believe that, so far as an anchorage is concerned, it should be shown as clay. Not having any means of ascertaining, I recorded such as obtained. I suggest, therefore, that the party operating in that vicinity, or even anywhere the coming season, be furnished with gas-pipe, in sections not exceeding 4 feet, (in length,) the whole being about 50 feet in length for this purpose.

October 1, we left camp for Michigan City to lay up the boats, and on the 3d started with the party for Michigan Southern and Lake Shore Railroad for Detroit, where we arrived the next morning.

The following is a summation of the season's work, viz:

Buoys set	335
Stations built	544
Pointings of theodolite	8,542
Readings of theodolite	10,345
Shore-line run, (in miles)	157
Lines of soundings	2,181
Casts of the lead	59,101
Observations for meridian	15
Observations for magnetic variation	118
Triangles measured and computed	59

The following shows the distances between the several azimuth stations, with the differences in azimuth of lines about midway between them, as shown by carrying the azimuth in both directions till meeting in a common line.

	Distance.	Difference of azimuth.
	Miles.	° ′ ″
Triangulation observation-point 1 to triangulation observation-point 2	12 1-8	= 0 01 24
Triangulation observation-point 2 to triangulation observation point 3	11 7-8	= 0 01 55
Triangulation observation-point 3 to triangulation observation-point 4	19 3-8	= 0 04 06
Triangulation observation-point 5 to triangulation observation-point 6	19 3-16	= 0 02 30

This shows the maximum error or difference in azimuth in the meander of the shore-line.

In no case could I carry the azimuth from one azimuth station to another without several intermediate stations.

During the latter half of the season the progress of the work was greatly impeded by sickness of the party. Not only was I deprived of my most valuable aid, Mr. C. F. Harrington, but my own health and that of the entire party was such that a great amount of time was lost. At one time the whole party had to remain idle on alternate days, as no one was able to direct the work.

Allow me to express my gratitude to Messrs. F. G. Bulkley, W. C. Sauer, V. M. Spalding, and especially to Mr. C. F. Harrington, for the ability and cheerful perseverance with which they did everything required of them.

As suggestions are called for, allow me to recommend the following as in my opinion the best outfit in instruments for a shore party:

One good 10-inch theodolite, with vertical circle and transit telescope and good compass, (similar in all respects, with the exception that it should be heavier, the leveling-screws farther apart, and generally more substantial, to No. 64 Würdemann for shore-line, &c.)

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A second theodolite, similar to the above in all other respects, except that it shall be lighter, and may read to 1′ only, (for topography, &c.)
One sextant similar to No. 1 Würdemann.
Very respectfully submitted.

LEWIS FOOTE

General C. B. COMSTOCK,
Superintendent United States Lake Survey.

No. 75.] UNITED STATES LAKE SURVEY OFFICE
December 12, 187[illegible]

SIR: I have the honor to make the following report in compliance with your instructions:

Report of work accomplished.

Nature of work.	On Lake St. Clair.	On the Saint Lawrence River.	Total amounts for the season.
	Spring of 1871.	Summer of 1871.	
Buoys placed out	14	.....	
Triangulation stations	27	290	
Sounding stations	18	739	
Lines of soundings	83	493	
Casts of the lead	4,509	5,906	
Theodolite pointings	791	19,410	
Theodolite readings	1,433	20,359	
Miles of shore-line	24	125[illegible]	
Polaris observations	3	3	
Compass readings	16	25	
Square miles topography	.....	58	
Square miles hydrography	13	31	

Very respectfully, your obedient servant,

A. C. LAMSON.
Assistant United States Lake Survey.

General C. B. COMSTOCK,
Major, Corps of Engineers, U. S. A.

No. 74.] DETROIT, *December* 12, 187[illegible]

SIR: Agreeably to your circular of 11th instant, I have the honor to report to you the amount of field-work done by my party from April 17, 1871, to September 26, 187[illegible] on the east shore of Lake Saint Clair, between Belle Rivière and Baptiste Creek, and on the west shore of Lake Michigan, commencing at sounding station 8 Ada, one mile south of Amsterdam, and ending at sounding station 6 A, N, L, four and a half miles south of Oak Creek, Wisconsin; and also, I beg to present to you the following remarks:

From April 17, 1871, *to September* 26, 1871.

Sounding stations	1[illegible]
Stake stations	[illegible]
Secondary triangulation stations	
Buoys placed and located	1[illegible]
Pointings of the theodolite	6,[illegible]
Readings of the theodolite	6,44[illegible]
Vertical angles	1,13[illegible]
Miles sounded	[illegible]
Lines sounded	1,11[illegible]
Casts of the lead	3[illegible]
Miles of shore-line	
Square miles of hydrography	[illegible]
Roads run with stadia, (miles)	
Miles of topography	[illegible]
Square miles of topography	[illegible]
Meridian-lines determined	
Base-line measured	

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In reference to the measurement of distances with the stadia instead of the chain. I found a way of using the stadia without being held during the time of the reading of the distance, in order to avoid any shaking. I made a tripod and fixed the instrument to it and placed it in a *vertical position*, with a plumb-line. The stadia ought to be made of one piece, and the lower extremity to be protected from wearing out with a sharp iron shoe, which is driven in the ground. This new mode of using the stadia has been entirely successful.

A wooden meter-standard, divided in decimeters, is needed for adjusting the meter-chain. The ends of it ought to be cased with steel. The meter-chain wants brass tags at every fifth meter link, with stamped figures.

A new plane-table was sent to me at my camp at Oak Creek, on the 19th of September, 1871. It was too late for making any use of it, being on the eve of moving my camp to the Detroit River, according to your orders dated Milwaukee, September 18, 1871.

I have examined that plane-table, which I found well executed, but made according to the old system. For topography the whole concern is too bulky and heavy; and the horizontal spider wires of its telescope want to be re-adjusted; they are too far apart for any stadia measurements.

A light plane-table of 18 inches by 15 inches, with all the improvements, would answer for sketching topography, the shore-line being run with the chain or the stadia and the azimuth angles observed with the theodolite.

The theodolites No. 84 and No. 98, which I used during the last season, do not need any repairs.

The two heavy sounding-boats which I had this year are to be condemned. It would be more advantageous to have some lighter ones built, pulling 6 oars; they would answer better for sounding work.

Very respectfully,

J. R. MAYER,
Assistant Lake Survey.

Major C. B. COMSTOCK,
United States Engineers, Sup't Lake Survey, Detroit.

OFFICE UNITED STATES LAKE SURVEY,
December 12, 1871.

SIR: I have the honor to submit the following report of work done by my party during the season just past:

Report of work accomplished.

Nature of work.	On Lake St. Clair. May, 1871.	On the Saint Lawrence River. 1871.	Total amount for the season.
Casts of lead	21,385	10,898	32,283
Number of lines of sounding	298	714	1,012
Number of miles of shore-line	39	154½	193½
Theodolite pointings	2,665	14,146	16,811
Vernier readings	3,017	16,665	19,682
Triangulation stations built	20	234	254
Sounding stations built	87	1,298	1,385
Square miles of topography	.....	61	61
Number of observations for azimuth	.....	6	6
Compass readings	.....	20	20
Number of buoys located	61	4	65
Square miles of hydrography	43	29	72

The theodolites Nos. 89 and 99 are in good condition; also the plane-table.

Very respectfully, your obedient servant,

F. M. TOWAR,
Assistant United States Lake Survey.

General C. B. COMSTOCK,
Major, Corps of Engineers, U. S. A.

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APPENDIX A. A.

REPORT OF CAPTAIN W. A. JONES, CORPS OF ENGINEERS, OF A SURVEY AND EXPLORATION IN THE UINTAH MOUNTAINS, UTAH.

HEADQUARTERS DEPARTMENT OF THE PLATTE,
UNITED STATES ENGINEER OFFICE,
Omaha, Nebraska, June 7, 1872.

SIR: I have the honor to forward to you, herewith inclosed, a copy of my report to the brigadier general commanding this department of a survey and exploration in the Uintah Mountains of Utah, together with tracings of the two maps which accompany the same.

Very respectfully, your obedient servant,

W. A. JONES,
Captain of Engineers.

The CHIEF OF ENGINEERS, *U. S. A.*,
Washington, D. C.

HEADQUARTERS DEPARTMENT OF THE PLATTE,
ENGINEER OFFICE.
Omaha, Nebraska, March 26, 1872.

SIR: Referring to paragraph 4, Special Orders No. 101, series of 1871, from these headquarters, directing me to make certain surveys and explorations in the Uintah Mountains of Utah, and to letter of instructions dated June 10, 1871, specifying the objects of the expedition to be as follows, viz.:

1. To ascertain the character and extent of the valleys of the streams, and their adaptability to cultivation or grazing.
2. To ascertain the character of the timber, its amount, location, and the feasibility of getting it to the railroad.
3. If possible, to find a practicable wagon-road from Fort Bridger to the Uintah Indian agency.
4. If practicable, to examine the country on Green River with reference to the coal mineral deposits reported there. Generally, to give all useful information concerning the country examined, which is now comparatively unknown.

I have the honor to report: 1st. That I left Omaha on the 11th June, 1871, and on the 14th arrived at Fort Bridger, Wyoming Territory, with two assistants, one topographer and one flag-man, who had left Omaha one day later. From this date until the 20th of June the time was occupied in making a system of triangulation with a view primarily of locating accurately the axis of the mountain range which was to be examined, as well as in the necessary preparations and outfitting for the expedition. On the 29th of June the expedition left Fort Bridger and moved to a point on Smith's Fork, nine miles distant. It consisted of myself and two assistants, with an escort of one corporal and six men, under command of Lieutenant W. W. Wood, Thirteenth Infantry. For transportation we had one wagon, (six mules,) and one ambulance, (two mules,) with one teamster and one mule-packer. The intention was to proceed as far as possible with wagons and then send them back and proceed with a pack-train. On the 6th of July we moved fourteen miles up the west branch of Smith's Fork, over a road constructed by Judge W. A. Carter to one of his saw-mills. This march brought us into the heart

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timbered foot-hills of the mountains. 9th July we moved up the same stream ten miles to a point near another saw-mill and three miles from the terminus of Carter's road. Up to this point the timber is white pine and aspen, with a little cedar, the aspen gradually disappearing as the altitude increases. Openings of meadow with rich pasturage are numerous. 12th July moved eastward across the divide to the east or main branch of Smith's Fork, over a road roughly cut through the timber by Lieutenant-Colonel Gilbert, Seventh Infantry, in 1869. After examining the country toward the summit, I had the road cut to a point about three miles farther up the stream, and moved there on the 15th of July. This spot was selected as being the most favorable from which to look for a "pass," and the axis of the mountains. On the 20th of July I examined the "pass" discovered by Colonel Gilbert, at the head of the stream on which we were camped, and found the approach on the eastern side of the valley practicable for a wagon-road. Also that another stream flowing to the south took its rise within one-half a mile from the head-waters of this stream. The wagon and ambulance, with extra camp equipage, were sent back to Fort Bridger on the 22d of July, to be replaced by a pack-train. On the 23d of July I located the anticlinal axis of the range, which at this point bears north 77° 48′ east from the true meridian, and passes along the northern slope of Gilbert's peak, which lies in latitude 40° 45′ 10″ north, and longitude 110° 29′ 40″ west of Greenwich. This peak has an altitude of 13,250 feet above the sea. Mount Hodges, lying amidst a mass of high peaks a little to the south and east of this point, has an elevation of about 13,500 feet; and Mount Tohkwana, a sharp peak at the head of Black's Fork, has a measured altitude of 13,500 feet. During the day four lodges of Ute Indians came in, three of which accompanied us to the agency. On the 27th of July the pack-train arrived from Fort Bridger. The serviceable animals which were sent back had been replaced by a lot of which the greater part were "condemned," and only two were really efficient as pack-mules. This circumstance will account for the very limited operations of the expedition. It was impossible, with this train, to make much progress in such a broken, heavily wooded, and trackless country. On the 29th of July we moved across the "pass" to the head-waters of a branch of Lake Fork, a distance of twelve miles. The head-water valleys of these two streams, which flow down opposite sides of the mountains, are very similar. They are the results of erosion in the soft sandstone-rock, forming enormous basins amphitheatrical shaped at the head, and merging into sharp, narrow valleys lower down, with slopes very rugged, with bowlder *débris*. A good deal of marsh and meadow occur along the water-courses on the north side. Timber and grass are abundant, the former mostly spruce and trailing cedar, while the latter grows quite up to the summit both in the valleys and on the ridges. This pass is easy of access, bowlder *débris* being the principal obstruction in the approach. The valley on the south side is much the rougher. The streams make a very rapid descent with considerable falls, and run through bad cañons in the gorge of the valley. After reconnoitering the country and finding the adjacent valleys more rugged and cut up with cañons than the one we were in, I started the train on the 31st July down the west side of the cañon, but was obliged to stop it after a march of six miles, because of an impassable lateral cañon about three miles farther ahead. After examining the valley below to the debouch of the cañon, the train, on the 2d of August, was moved down to this point by following down the left bank of the stream; distance, twelve miles. This was a very difficult march, not so much on account of surface of

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the country as of the dense growth of small timber and the inefficiency of the train. On the 3d of August we marched twelve miles and came to the open country, where the valley was about one mile wide. This day the Indians moved rapidly ahead of us, and maliciously set fire to the woods at a point where the valley was still very narrow. As we were in the woods with the wind blowing toward us, there was nothing to do but march through the burning district and get to the windward of it. This was attended with much difficulty, and the risk of loss of some animals, but was fortunately accomplished without loss. The stream, which I have called Big Spruce Creek, takes its rise, like most of the streams in these mountains, at the summit, in a huge, deep basin, which is somewhat semicircular, and from two to three miles wide at the head, but rapidly closing in about nine miles below to a narrow gorge-like valley, where the steep, wooded slopes come down frequently to the very edge of the cañon, through which the stream runs. On the northern slope of the mountains, however, the gorge portions of these valleys are much wider, less rugged, while the cañons are of little or no extent. Many of the valleys on the southern slope are impassable in this gorge-portion on account of the numerous lateral cañons. Big Spruce Creek makes two considerable falls before entering its cañon, through which it makes a very rapid descent. This latter is generally about 100 feet deep, with vertical walls of red sandstone. It has a width which varies between 100 and 200 feet, and is about four or five miles long. It is probably a transversal crack, that opened when the mountains were uplifted. There is no grass in this gorge, but an abundance both above and below it. The timber is spruce, white pine, aspen, and a little hemlock. The spruce is very fine. We remained in camp until the 5th of August before proceeding, as several of the mules were unable to go farther without rest. On the 5th of August we moved ahead, and soon struck the mountain trail from the agency to the Mormon settlements, which skirts along the wooded foot-hills of the mountains, marching eighteen miles. All of the mountain streams between Big Spruce Creek and North Uintah River, a distance of twenty-five miles, were dry at this season, or nearly so. Probably they cannot be depended upon for water later than July or August. The only water is at the spring where we encamped, where the supply is probably unfailing. On the 6th of August we moved to the Uintah Valley agency, distant thirteen miles. Grass is abundant in the valleys and neighborhood of the springs, which latter are generally dry at this season. Sage-brush and sparse bunch-grass are found almost everywhere on the high ground below the foot-hills, on which latter are some fine groves of yellow pine.

The agency is located on the east or left bank of the North Uintah River, at a point where a tributary creek joins it from the east. The valley here widens out and displays a flat meadow of rich soil, covered with an abundant growth of grass, with cotton-wood and willow trees along the streams. The Indian farm is irrigated from the river. Wheat, corn, oats, and the hardy vegetables are cultivated upon it. The altitude above the sea is 6,000 feet, or about 1,200 feet lower than Fort Bridger. This, combined with the location south of the mountains in an inclosed basin, renders the climate much more salubrious and favorable to agriculture. The snow-fall is comparatively light. More rain falls during the summer than at Fort Bridger, but not enough for the cultivation of land. About forty lodges of the Ute Indians were present at the agency. The maximum in the winter season has of late been about one hundred and fifty lodges. As a general thing, they move out

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in the spring, taking the trail to Brown's Hole; thence, they have a trail along the wooded foot-slopes on the north side of the mountains to the Mormon settlements in the Wahsatch Mountains. From thence they have their trail correspondingly located on the south side of the mountains, back to the agency, along which they sometimes return in the fall, but generally they retraced their steps by way of Brown's Hole. Along the route there is almost everywhere a superabundance of grass, wood, and water; the woods abound with large game, elk, deer, and bear, while the streams swarm with trout of a very superior quality. Beaver are also tolerably numerous. Here these Indians spend the hunting season, in a climate incomparably fine, making occasional trading excursions to Fort Bridger and horse-stealing raids on the Mormon settlements in the Wahsatch. They have a bitter enmity toward the Mormons, regarding them as a distinct and inferior tribe to the white man.

I remained at this point until the 9th of August, resting the animals and getting them shod, and then started back to Fort Bridger over what is known as the Sheep Creek trail, making a march of sixteen miles. One mule was found, from old age and exhaustion, to be utterly unable to proceed, even without a pack, and was abandoned at the agency. After leaving the latter, the soil along the route for about eight miles is composed very largely of yellow and red marls, carrying a sparse growth of sage-brush and scrub cedar, after which there is a good deal of fertile meadow. The water along the march is poor, and cannot be relied on later in the season, but there is good water and grass at the spot where we camped. Wood is a little scarce. On the 10th of August we moved twelve miles, to Ashley's Fork. The trail passes for the first five or six miles through a fine forest of red cedar, a good deal of which has large straight trunks, very suitable for lumber. A few miles west of Ashley's Fork the trail crosses the outcropping of a fine bed of alabaster. Having observed along the latter portion of the march some *débris* of what appeared to be a copper-ore, I made an examination of the adjacent country after reaching camp, and found a deposit of silicate of copper on the face of the cañon of Ashley's Fork, near its debouch. I saw also along the route some indications of a bed of iron-ore, (brown hematite.) This was the first day since leaving Fort Bridger that I had seen such indications of metalliferous deposits as would lead me to examine the country for them.

On the 11th of August I made a further examination, and found another bed of silicate of copper in the hills, about three miles west and north from camp. Ashley's Fork is a stream of considerable size. It debouches from the mountains at a point just above where the trail crosses it, through a tremendous cañon in yellow sand-stone. Below this, it runs through a narrow valley, its banks bordered with cotton-wood and willow, and but little grass. On the 12th of August the train was marched eleven miles. About one mile from the stream the trail branches to the left from the one to Brown's Hole, and strikes directly across the mountains. Along it the slopes are covered with a good growth of short grass, with some extensive groves of aspen, and forests of white pine, having some fine meadow interspersed. The soil is good. We camped in a large, beautiful meadow, holding a number of springs, and surrounded by groves of aspen and pine. There is no water between this point and Ashley's Fork. The trail crosses several heavy veins of quartz, (perhaps metamorphic sandstone.) In one of them I found decomposed iron pyrites. August 13th we marched fifteen miles to a point near the summit. The trail this day ran through alternate meadows and open forest of white pine. We

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camped in the woods, on the borders of a meadow that was particularly noticeable, it being from six to eight miles long, and about one mile wide, with a small stream running through it. There was good grass in the forest, but I did not examine how far in from the edge the grass extended. I cannot refrain from calling attention at this point to the peculiar adaptabilities to grazing of the elevated region which I have just been describing. Grass is everywhere abundant, and the summer climate surprisingly fine. During the rigor of winter, stock could be comfortably sheltered in the Uintah Valley, and along the foot hills. Of course, at such an altitude (about 10,000 feet) the great radiation of heat during the night lowers the temperature to below the freezing point of water before sunrise nearly every morning, so that, although the soil is quite rich, agriculture can never succeed to any extent.

On the 14th of August we marched ten miles. The trail leads through a rough, densely-wooded country, and makes a considerable descent on the northern slope of the mountains. Water and grass along each end of the march, but grass is scarce along the middle portion. From a point about ten miles west of where this trail crosses to the Green River the summit of the mountains is below the superior limit of tree growth, and the range is wholly covered with forest. On the 15th of August the train was moved fifteen miles, and reached the open country about eight miles from Henry's Fork. Along the trail, as far as Sheep Creek, grass and water occur, but from that point there is no water and very little grass, except at a small stream about three miles from it. The ridges are very steep and rugged, with a heavy growth of pine and hemlock on the north side only. The soil is in many places very sandy. On the 16th of August I examined the country along the previous day's march, and found the outcropping of a bed of iron-ore, (brown hematite.) This region is traversed by enormous seams of quartz, which strike conformably to the adjacent strata, but dip very nearly 90°, the latter having a dip of about 45° to the north, 7° 48′ east. I found fossil bivalve shells in this quartz, which had not been obliterated by the metamorphism. The country between this and Green River is broken up with upheavals in a variety of directions, and is consequently extremely rugged. On the 17th of August we moved fifteen miles. A march of eight miles brought us to a ranch on Henry's Fork, from which there is a wagon-road to Fort Bridger. Wood, water, and grass were abundant. On the 18th we marched twenty-four miles to a ranch on Smith's Fork, six miles from Fort Bridger. The road passes through a remarkable formation of tertiary marls and green sand, called the "Bridger Bad Lands." This deposit is of immense thickness and worn by erosion into huge yellow bluffs and hills, destitute of vegetation, showing on their slopes a water-tracery that bears a wonderful association to the forms of Gothic architecture. On the 19th of August we returned to Fort Bridger.

2d. Geologically, the Uintah Mountains are the result of an upheaval not long subsequent to the carboniferous epoch. In this upheaval a great belt of country, from twenty-five to thirty miles wide, was raised to the extreme elevation, without materially disturbing the original inclination of the strata; it being possible that the present dip, which increases from 2° 5′ at the summit to about 4° at the southern edge, is the same that existed before the mountains were lifted. Upon both edges of this belt the strata are broken axially, dipping on the north side 38° to the north, 12° 12′ west from the true meridian, and on the south about 43° to the south, 12° 12′ east, in the longitude of Gilbert Peak. The main anticlinal axis is on the north edge, and in the same

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longitude bears north 77° 48′ east from the true meridian. The uplifted beds, as displayed by the lateral erosion, are almost entirely composed of a brownish-red sandstone, rarely, if at all fossiliferous, of the sub-carboniferous epoch, the color rarely changing into gray, and metaphorphosed into quartzite along the anticlinal cracks. They are of very great thickness, from 2,500 to 3,000 feet, being visible near the summit. Higher up in the series, and lying along the base of the mountains toward Green River, the carboniferous beds of soft, bright yellow sandstone, coarse conglomerate, blue limestone, (quite rare and thin,) and gypsum, (in their seams,) are exposed. The whole region adjoining Green River is traversed by immense veins of quartz and metamorphic limestone. I have inferred the former to be a metamorphic sandstone, from the fact of having found fossil-shells in it. These strata, at the point where Sheep Creek Trail crosses, strike to the east 7° 48′ south from the true meridian, and have about the same dip as the rocks at the summit; from which I infer that the axis of the mountains is flexed horizontally to the northward. The igneous rocks have not been protruded through the axial cracks, and are only slightly seen in the immense section made by Green River through the eastern extremity of the range. The series above the carboniferous either do not occur, or are overlaid by a highly fossiliferous deposit of tertiary age. This deposit lies nearly horizontal, and is composed of soft yellow and red marls, green-sand, and thin beds of soft limestone and chert. It is immensely eroded and terraced on both sides of the mountains. Along the main anticlinal axis, and especially across the uplifted belt previously alluded to, are numerous lateral cracks that have been the starting-points of an amount of erosion that seems wonderful. They have been worn into enormous basins from 2,000 to 3,000 feet deep, from two to three miles wide at the head, and narrowing to a cañon or precipitous valley about eight or ten miles below. Those on the north are generally worn quite across the axis into the high belt beyond. This elevated strip is badly broken up by cracks in various directions, and some of the peaks seem to have been crushed into a mass of huge bowlders. There is so much of this bowlder *débris in situ*, and so many cañons, that progress in any direction through this part of the range is attended with extreme difficulty.

3d. Topographically, the Uintah range is a spur which leaves the Wahsatch Mountains in latitude 40° 30′ north nearly, with an altitude of about 12,500 feet; thence tending northeasterly by a curved line which turns a little south of east before reaching Green River, where it virtually terminates. The extreme elevation is reached in the vicinity of Gilbert's Peak, where Mount Hodges and Mount Tohkwana have an altitude of 13,500 feet. The range forms an immense ridge with an almost level but badly broken-up belt on top, which has an elevation of about 6,000 feet above the table-land on the north, and about 7,000 above the similar table-land on the south. The valleys are numerous, deep, and narrow, except at the head, and extend quite to the summit. Between them, on the north, are the transverse and generally unbroken ridges, by means of which the summit can be reached by a gradual ascent. On the south, these ridges are badly broken toward the summit. The enormous basins previously described, ranged along either side of the summit-line, have a direction considerably oblique to that of the prevailing winds, and, in consequence, the amount of snow that drifts into them during the winter must be enormous. At such an altitude this snow melts comparatively slowly, and furnishes an almost continuous supply of water to the very numerous mountain-

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streams, much of it having first been caught in the multitude of little lakes which are sprinkled around the border of the basins. On the north side there is a good deal of marsh in these basins, but on the south, the water having to make about 1,000 feet more descent, runs off too rapidly to leave any marsh. This circumstance, combined with the greater heat of the southern exposure, makes many of the smaller streams on this side run dry early in the season.

The opposite valleys frequently start from very nearly the same point, and have between them only a thin precipitous wall, which erosion is slowly removing. Gilbert's Pass is such a point, where the wall has been sufficiently worn away to admit of the construction of a road across it. There are probably few if any other such places at present. The belt or strip at the summit is broken and eroded enormously. Ridges of high peaks extend across it between the valleys and many narrow precipitous cañons occur, both along the valleys and transversely to them. The sides of these ridges are generally masses of bowlder *débris* in situ. The country extending northward and southward from the base of the mountains is an elevated, highly-terraced plateau of soft earth, the slopes of the terraces being generally as steep as the earth will stand and frequently quite barren.

4th. The streams heading in these mountains are characterized by main features which are common to all. Taking their rise in the summit basins, they flow, on the north side, through narrow gorge-valleys with steep, heavily-wooded slopes, until they emerge from the foot hills into the terraced plateau, which abuts against the base of the range. Here the valley spreads out to a width which thenceforward varies from one-fourth of a mile to one mile. The soil is rich and pretty generally covered with grass. Willow and cottonwood grow near the water, with rare groves of pine near the mountains. On the south side they take their rise in the same manner, but generally flow through precipitous cañons, while making their way through the gorge-valleys. The descent is very rapid, and there are many falls and cascades. The valley slopes, although largely covered with a growth of pine, spruce, and aspen, are very steep and extremely rugged, owing to the bowlder *débris*. A terraced plateau, 1,000 feet lower than that on the north, lies along the foot-slopes, and forms the Uintah Valley. Through this the streams have the same character as in the north, but, owing to the milder climate, vegetation is more luxuriant in the valleys, and some yellow and white pine are mingled with the cottonwood and willow that fringe the streams. All of the streams of this range are quite small, Bear River being the only one that is large enough to float logs, on the north side. Ashley's Fork and North Uintah River, on the south, are about the same size as Bear River. On the northern slope the supply of water in them is, in most if not all, continuous throughout the year. Above the plains this water is almost pure, from the fact of its flowing over nothing but sandstone. This quality, together with its great coolness, makes the head waters of these streams the favorite abode of a very superior kind of mountain trout. Below the superior limit of tree-growth, which is at an altitude of about 11,000 feet, the mountain-ridges are covered with a dense forest, very much interspersed with small open meadows, with their grass often spreading itself for a considerable distance into the timber. Everywhere, even to the borders of the snow-banks at the mountain-summit, there is a luxuriant display of flowers, and the grasses thrive along the summit of the ridges above the superior limit of tree-growth, and quite up to the summit of the range. The soil of the plateau, between the streams, is almost exclusively yellow marl, mingled with, and over-

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lain in many places by, local drift from the mountains. It is quite rich, and, under different climatic influences, competent to sustain vegetation. At present, only sage-brush, grease-wood, and bunch-grass grow upon it. I saw on the south side several places where the Indians had burned off the sage-brush once or twice, and it had been replaced by the bunch-grass in a much heavier growth than before the fire. The Indians say that they can make pasture for their ponies this way. It is certainly a noticeable fact that on this side, where they burn over the country a good deal, there are very many extensive patches of this "high and dry" pasture. In treating of the adaptability of this country to the purpose of agriculture, two separate regions will be considered, which have essential differences of soil and climate. The (1) plain region comprises the terraced plateau of tertiary marls which skirts both sides of the mountains, as previously described. The soil is the same in both, and is generally quite rich. The climate on the north is well represented by that of Fort Bridger. It is characterized by wide variations of temperature at all seasons, a very low degree of humidity, a merely nominal rain-fall, and a good deal of westerly wind. Spring opens in May, and winter sets in about December. Only such plants as will stand frost, both in the early and later stages of growth, can be cultivated with certainty, and irrigation is always essential.

There is good grazing in the bottom-lands, along the water-courses, and a sparse growth of bunch-grass on the higher ground. On the south, for reasons already set forth, the climate is sufficiently mild to admit of successful cultivation of the soil, but irrigation is always necessary. There is good grazing along the valleys, and grass is much more abundant on the high ground than on the north. Of late years the grasshopper has been an additional element of uncertainty in the raising of crops in the whole of this plateau region. (2.) In the mountain region the soil is quite rich, carrying an abundant vegetable mold. It is thin, however, on the ridges. There is a sufficient rain-fall to sustain an abundant vegetation, which latter must be of an extremely hardy character, as the diurnal variation of summer temperature is quite large. The extreme daily cold, which is probably reached a little before sunrise, is often sufficient to freeze water in small vessels. On the whole, it is quite probable that a pastoral people could live quite comfortably in these mountain valleys, and successfully cultivate a large portion of the food necessary for their sustenance. The whole region, mountain and plateau, is essentially adapted to grazing. Grass is found everywhere, even to the mountain summit, and there is always water in the mountains. Resulting from the lesser altitude, and its sheltered situation, the climate of the Uintah Valley and the southern slope of the mountains is, in all probability, sufficiently mild to admit of winter grazing. The Ute Indians here have been quite successful in raising cattle.

A noticeable feature of this country is the scarcity of birds, reptiles, and insects. We only saw a few snakes and lizards on the southern plateau, at Ashley's Fork. Mosquitoes and deer-flies are very numerous for about six weeks in June and July, after which they disappear. The deer-fly is a ferocious insect, very much like the common horse-fly, but larger, and with irridescent colors, sometimes banded, of red, green, and yellow on the head. They go in swarms, attacking both man and beast, and are a terrible scourge to animals.

5th. The whole of the mountain slopes, from the edge of the terraced plateau to an altitude of about 11,000 feet, is covered with extensive forests of white and yellow pine, spruce, red cedar, hemlock, and aspen.

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Nearly all that I saw was of young growth. There is every evidence that extensive fires have raged here at intervals over a long period. The trees are not of sufficiently large growth to make first-class lumber, but for most other purposes, particularly for square and hewn timber in length reaching up to 50 feet, it is admirably suited. I know of only one way of getting it to the Union Pacific Railroad, and that is by hauling, either on wheels or sleds. Bear River is the only stream that is ever large enough to float logs, but it cannot always be relied upon. Judge Carter, of Fort Bridger, has a project for a railroad from Church Buttes station to the mountain forests, which, from an examination of the country, seems to be perfectly feasible, from an engineering point of view.

6th. With regard to a wagon-road from Fort Bridger to the Uintah Valley agency, I have found upon examination that the pass at the head of the main branch of Smith's Fork, which was discovered by Lieutenant-Colonel Gilbert, Seventh United States Infantry, affords a practicable means of passing the summit, although lying in the vicinity of the most elevated portion of the range. It is at an elevation of about 11,000 feet above the sea, or 4,000 feet above Fort Bridger. The ascent is sufficiently gradual to make the construction of a road-way a matter of comparatively light expense. The approach can be made up either branch of Smith's Fork. The route my party took was up the west branch. A wagon-road has already been opened by Judge W. A. Carter, along this route, three miles beyond his saw-mill, near its head. From this point a road has been cut through the heavy timber across the high divide to the main or east branch. Along this latter road there are some very heavy grades, but they could probably be much reduced by zig-zags, and a more careful selection of the ground. The obvious approach to the pass, however, is to follow up the east branch from the first, it being palpable that the increased cost of transportation involved in getting across the divide between the west and east branches, and the difference of level to necessarily overcome between Fort Bridger and Carter's mill, would in a short time more than equal the amount in first cost saved by adopting the road already constructed by Judge Carter. It was suggested to me that the divide might be crossed more easily at a point higher up than that chosen by Colonel Gilbert, but a careful examination failed to satisfy me that this was the case. I have therefore indicated on the map, as the preferable route, one following up Smith's Fork, and its main or eastern branch, keeping as a general thing on the eastern slope of the valley. From camp No. 5 to the summit it will be necessary to keep altogether on this side. Along here I tried to take the pack-train over the route selected, so that by blazing the trees our trail might be easily found hereafter; but in the thick forest we went astray for a short distance, and the blazing, therefore, does not lead over the best ground for the road. It was only for a short distance, however. The principal obstructions to be overcome in constructing the road up to the pass will be found in the basin at the head of the stream and at the pass. They are, in the first case, marsh and streams of bowlder *débris*. The former is probably shallow, and there is plenty of timber to "corduroy" it with. The latter can be easily overcome by filling the crevices with stones of smaller size, and covering the surface with broken stone of tolerably small size, making a rough macadamized way across. At the pass there is a sharp but very short ascent on either side, which can be overcome by zigzagging. A great deal of bowlder *débris* occurs about this point. It is of small size, however, and no serious difficulty need be experienced on account of it. Little, if any, bridging will be required on this sec-

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On the south a practicable route will be found along the left bank of a stream which I have called Big Spruce Creek, to its junction with Lake Fork; thence along the latter to where the road from Salt Lake City to the agency crosses it; thence along the latter to the agency, as indicated on the map. Three or four small bridges will be required. There is no marsh, but considerable bowlder *débris*. At the point where the creek debouches from its cañon it winds close around a sharp rocky point, where a little blasting will probably be necessary. The rock, however, is soft sandstone, and very much broken up. As will be seen from an examination of the map, the proposed route is mostly through the timber region. During the season of snow it will be impracticable, as the drifted accumulations of snow in the basins must be enormous. The distance from Carter, on the Union Pacific Railroad, to the Uintah Valley agency by this route is one hundred and four miles. At present, the only route of supply for this agency is via Salt Lake City, over a road that crosses the Wahsatch Mountains near the head-waters of the Timpanogas River, thence down the De Lorme Fork of Uintah River to the valley. The distance is variously estimated to be from one hundred and eighty to two hundred miles. It is reported to be quite rough, and is not practicable in winter. A comparison of this with the proposed route shows that a distance of one hundred and sixty-five miles by rail, and about eighty-five miles by wagon-road, will be avoided by the latter, while the general conditions of grades and climate are about the same in both. Carter is a station on the Union Pacific Railroad, distant eleven miles from Fort Bridger.

7th. I did not find it practicable, with the transportation furnished me, to make an examination of the Green River country.

The first indications of metalliferous deposits that I met with were in the vicinity of Ashley's Fork. Here the "float" rock gave evidence of the presence of iron and copper. Of the former I found numerous specimens of "bog" ore, probably dissolved by water and carried away from some neighboring bed of "brown hematite." Not far from our camp on Ashley's Fork I found the outcrop of two veins of silicate of copper lying conformably with the beds of yellow sandstone, probably, and associated with thin seams of soft yellow limestone, the latter highly disposed to crystallization in the form of dog-tooth spar. Thin seams of selenite occur in this vicinity, in heavy bed of red marl overlain by coarse conglomerate. A bed of pure alabaster, about 10 feet thick, outcrops on the trail a few miles west of Ashley's Fork. Between this latter and the summit of the mountains, along Sheep Creek trail, occur a few enormous seams of quartz associated with blue limestone. The "country rock" is red sandstone. Some of this quartz is impregnated with iron pyrites in the form of minute crystals much decomposed. Between the summit and Henry's Fork the ridges of upper carboniferous rocks are traversed by extensive veins of metamorphic limestone and quartz, (probably metamorphic sandstone.) In this region I found one bed of brown hematite (iron) ore associated with these metamorphic veins and blue limestone. From what I consider reliable information, I have ascertained that in the immediate vicinity of Brown's Hole and east of Green River veins of carbonate of copper associated with silver in a gangue of quartz rock occur, but that so far none have been discovered of sufficient thickness to be of workable value. From my own observation, as well as that of Mr. Emmons, who was in charge of one of Mr. Clarence King's parties which made a thorough examination of the whole Uintah range, I am of the opinion that, except near the eastern extremity, there is little probability of the occurrence of metalliferous

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ous veins carrying the precious metals in the Uintah Mountains. Small specimens of auriferous quartz have from time to time been discovered, and a "color" obtained by washings on the northern slope, particularly in the vicinity of Bear River; but they, in all probability, came from a bed of very coarse conglomerate, carrying small *débris* of gold-bearing quartz-rock, which Mr. Emmons found outcropping near the head of Bear River. Coal probably occurs along the base of the mountains on either side; but I saw no indications of it.

To accompany this report I have had prepared a map of the "Uintah Mountains and vicinity," and also a map on a larger scale to illustrate the proposed wagon-route. They are inclosed herewith.

The altitudes given are barometric, and are those obtained by Mr. Emmons, of Mr. Clarence King's party, to whom I am indebted for much valuable information, and by Dr. Hayden.

A day or two before leaving Omaha I was so unfortunate as to get the only barometer in this office broken in such a way that it could only be repaired at the maker's; and my hygrometer was accidentally broken shortly after leaving Fort Bridger. The distances given after we first crossed the mountains are approximate, as I had not sufficient funds to make anything more than a simple reconnaissance.

I am, sir, very respectfully, your obedient servant,

W. A. JONES,
Captain of Engineers.

The ADJUTANT-GENERAL,
Department of the Platte.

APPENDIX B B.

REPORT OF LIEUTENANT E. H. RUFFNER, CORPS OF ENGINEERS, ON THE DETERMINATION OF DIFFERENCE OF LONGITUDE BETWEEN DETROIT, MICHIGAN, AND FORT LEAVENWORTH, KANSAS.

HEADQUARTERS DEPARTMENT OF THE MISSOURI,
FORT LEAVENWORTH, KANSAS, *Engineer Office, July* 10, 1872.

SIR: I have the honor to submit the following report on the determination of the difference of longitude between the observatory of the lake survey at Detroit, Michigan, and the observatory at Fort Leavenworth, Kansas. The method used was the transmission by telegraph of transits of stars. There was but one clock and one chronograph on the line, and these were at Detroit.

The observer at Detroit was Assistant O. B. Wheeler, United States lake survey; the instruments used being the Troughton and Sims transit, focal length 42 inches; clock No. 184, and chronograph 216, Bond & Son.

I myself observed at Fort Leavenworth with a Würdemann portable transit, No. 12, focal length 22 inches, and chronometer No. 1974, Frodsham, for instrumental stars.

The observations were made on September 1, 2, 7, and 20, 1871.

At the completion of the observations, I visited Detroit and made a series of observations with Assistant Wheeler for personal equation.

The notes were afterwards put into the hands of Professor T. H. Saf-

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ford, director of the Dearborn observatory, for reduction, and are here incorporated unchanged.

The wire intervals of the Detroit transit were taken as furnished, having been re-examined by Assistant Wheeler. The intervals of the Fort Leavenworth transit already observed for by myself were re-examined and corrected by comparison with intervals observed on the chronograph during the observations.

The following is the list of separate values of the difference of longitude as given by different stars, and measured by the Detroit clock:

	September 1.	September 2.	September 7.	September 20.
	m. s.	m. s.	m. s.	m. s.
ε Delphine	47 27.18	.....	.....	.....
α Cygni	.....	47 27.12	47 26.34	.....
μ Aquarii	.....	27.10	26.89	.....
ν Cygni	.....	26.53	26.35	.....
61 Cygni	.....	27.00	.....	.....
ζ Cygni	.....	27.38	26.73	.....
1 Pegasi	27.49	27.05	26.88	.....
β Aquarii	27.51	27.21	26.97	.....
ξ Aquarii	.....	27.02	27.07	.....
ε Pegasi	.....	.....	27.08	47 26.73
u Capricorni	.....	27.36	27.12	26.83
α Aquarii	27.24	27.23	.....	26.87
θ Aquarii	27.19	27.26	27.07	26.89
π Aquarii	.....	27.20	.....	26.73
η Aquarii	27.35	27.40	.....	26.62
ζ Pegasi	26.91	27.23	26.92	26.53
λ Aquarii	27.03	27.20	27.36	26.65
α Pegasi	.....	27.02	26.67	26.65
ν Piscium	.....	27.22	26.93	26.48
θ Piscium	.....	26.56	26.56	26.91
ι Piscium	.....	26.96	26.72	27.13
ω Piscium	.....	27.05	26.95	26.97
α Andromedæ	26.64	27.00	.....	26.91
γ Pegasi	.....	27.02	26.70	27.06
12 Ceti	27.38	26.95	.....	27.15
β Ceti	26.99	.....	.....	27.41
ε Piscium	27.00	26.91	26.56	27.21
ν Piscium	.....	.....	26.07	26.98
o Piscium	.....	.....	26.22	.....
Mean	47 27.16	47 27.08	47 26.77	47 26.88

Values of hourly losing-rate—Detroit clock.

September 1	0s.16	September 7	0s.21
September 2	0s.14	September 20	0s. 2

Trial values of longitude of Fort Leavenworth west from Detroit.

Date.	Number stars.	Uncorrected for rate.	Correction.	Corrected.	Personal error of single observation.	Personal error of all.
		m. s.	m. s.	m. s.	s.	s.
September 1..	12	47 27.16	+ 0.13	47 27.29	±0.173	±0.050
September 2..	24	47 27.08	+ 0.11	47 27.19	±0.145	±0.030
September 7..	21	47 26.77	+ 0.17	47 26.94	±0.210	±0.045
September 20..	19	47 26.88	+ 0.21	47 27.09	±0.161	±0.037
Mean	76	.....	47 27.11	.....	±0.171	±0.020

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PERSONAL EQUATION.

By the experiments made for the purpose of these observations, as well as by previous comparisons between the observers, Lieutenant Haffner and Mr. Wheeler, the personal equation was found to be of small amount, and about equally often positive and negative. It may safely be assumed as zero.

In taking the mean for a final value of the longitude, it would, perhaps, be desirable to give the observations of September 1 less weight; as in order to reduce them it was found necessary to employ the registered observations of longitude stars only; the instrument at Leavenworth seems to have shifted its position slightly; but the change thus produced would be exceedingly small. If they were omitted entirely, the longitude would be $47^m\ 27^s.07$.

It must be borne in mind that the probable errors given in the table do not include the probable uncertainty of the azimuth, or rather of Bessels N.

In reducing the observations, Bessels' formula of correction—

$$M + N \tan d + c \sec \delta$$

was preferred to Mayers'—

$$a \sin \frac{(O - \delta)}{\cos \delta} + b \cos \frac{(O - \delta)}{\cos \delta} + O \sec \delta$$

as in all cases simpler.

In longitude work by star-signals, the difference in clock-time can be at once corrected by the formula—

$$(M \div M) + (N \div N) \tan \delta + (c \div c) \sec \delta$$

when M' N' c' are the values for the westernmost station.

There being but one chronograph on the line, the loss caused by repeaters and wave-time could not be directly obtained. It so happened on the last night of observing, however, that the lines used passed via Kansas City, Saint Louis, Louisville, Indianapolis, and Chicago to Detroit, for a large part of the observations, instead of, as usual, direct from Saint Louis to Chicago. The introduction of the additional repeater and increased length of line did not show any difference in the observations; on the contrary the difference of longitude for that portion of the night was *less*, rather than greater, as should have been shown. I conclude, therefore, that the introduction of a correction for these telegraphic delays is uncertain, and, at most, the correction is much smaller than the errors of observation.

The difference of longitude of the present Lake-Survey Observatory and Washington, as determined last summer, was.....	$24^m\ 00^s.12 \pm 0^s.02$ W.
Difference, Detroit and Fort Leavenworth..	$47^m\ 27^s.11$
	$1^h\ 11^m\ 27^s.23$
Fort Leavenworth west of Washington....	$17^\circ\ 51'\ 48''.45$
Fort Leavenworth west of Greenwich.....	$94^\circ\ 54'\ 34''.95$

The present observatory at Fort Leavenworth is situated 945 feet west of the steamboat-landing.

Very respectfully, your obedient servant,

E. H. RUFFNER,
First Lieutenant Engineers.

The CHIEF OF ENGINEERS, *United States Army.*

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APPENDIX C C.

REPORT OF LIEUTENANT E. H. RUFFNER, CORPS OF ENGINEERS, OF EXPLORATIONS AND SURVEYS IN DEPARTMENT OF MISSOURI, IN THE YEAR ENDING JUNE 30, 1872.

HEADQUARTERS DEPARTMENT OF THE MISSOURI,
OFFICE OF THE CHIEF ENGINEER,
Fort Leavenworth, Kansas, August 13, 1872.

SIR: In obedience to circular dated Office Chief of Engineers, June 13, 1872, I have the honor to submit the following report of the operations of this office for the year ending June 30, 1872.

The summer season of last year began with an effort to cause the reports of scouts and marches to be made more accurate by the supply of reconnoitering instruments and material throughout the department, and by the preparation of careful instructions for their use. Continued neglect of these journals had made their re-establishment a very difficult matter, and the results of the season were very unsatisfactory and nothing of importance was recorded, although many movements should have given valuable information. The scarcity of officers, many scouts being made with but one officer attached, the absence of private soldiers acquainted with the method of recording, and the general idea that the "engineering" duty must, of necessity, be something of great difficulty, and had, therefore, better be let alone, conspired to produce this disappointment. To give all a basis to work upon, and to exhibit everything already known on a large scale, I commenced the compilation of a series of maps, on a scale of $\frac{1}{250,000}$, about an inch to four miles, intended to show exactly every detail, and give ample opportunity for correction and addition. The land survey township-plats of the different parts of the department were copied, commencing only where millitary operations might be considered possible. The number of plats copied was as follows:

	Townships.
Kansas, west of the sixth principal meridian	146
Colorado, all as surveyed	714
Indian Territory, Chickasaw Nation	84
New Mexico, partial	102
Total	2,046

These and everything else reliable were platted on the following maps:

Title.	Number of sections.	Scale.
Kansas	5	$\frac{1}{250,000}$
Indian Territory	1	$\frac{1}{250,000}$
Colorado	3	$\frac{1}{250,000}$
Colorado	Reduction.	$\frac{1}{1,000,000}$
New Mexico	One section.	$\frac{1}{1,000,000}$
Department of the Missouri commenced		$\frac{1}{1,000,000}$

Having caused my draughtsmen to learn to lithograph, the Kansas sections were hurriedly put on to stone and printed for use this summer as a ground-work. The last section was completed and issued just as the season's work commenced. Tracings of other sections have been furnished to the principal posts, when available, for addition thereto. The preparation of these maps, and the furnishing of the maps, plans, &c., ordinarily called for from this office, occupied the winter season.

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During the spring, upon the application of the general commanding, a detachment of Company E, Battalion of Engineers, consisting of one sergeant and four privates, was ordered to report to me. The men were instructed in the taking of reconnoitering notes, and at the opening of the season's marches were assigned to duty with the Sixth Cavalry on the march from Fort Riley to Fort Hays. After their arrival at this post two were retained for the Sixth Cavalry, now in camp near this post, and constantly engaged in scouting; two were sent to the camp of the Eighth Cavalry, on the Canadian River, and have since started on a prolonged and extensive march with all the available cavalry of New Mexico, down the Canadian, and over the Staked Plains to the headwaters of the Red River. The fifth private has gone to Camp Supply temporarily,

I have been exceedingly gratified with the results of this experiment. The men have all performed their duties well and with intelligence.

Their presence has caused all commanding officers to be more interested, and the officers on scouts feeling less compulsion, and seeing how simple it is, all take great interest, and the journals are very full, elaborate, and accurate. Reports have been received as follows, and in platting it is found that they all close to within 1 per cent., and the series altogether are more elaborate and accurate than any journals on file in this office from any source whatever:

	Miles.
March: Fort Riley to Fort Hays. Two independent journals	[illegible]
March: Fort Hays to Fort Dodge, (and return)	[illegible]
March: Fort Hays to Camp Supply	[illegible]
Scout: Fort Hays to Salnio and Solomon Rivers	[illegible]
Scout: Fort Hays to headwaters of Salnio and Solomon Rivers	[illegible]

This scout closed in platting to within one and one-fourth miles.

These scouts are to be continued until November 1, and by going in various directions, the character of the whole country and location of all settlements will be accurately done by that time.

Nothing has as yet, nor will be for some time, been heard from the expedition on the Staked Plains. I anticipate good results, as the sergeant, a very intelligent man, is along with this command. The vicinity of Camp Supply is being described and delineated as far as practicable.

In the spring I myself visited all the posts in the upper part of the department, and gave instructions to all officers on the use of instruments, and the keeping of notes. The appointment of Lieutenant Monson, Sixth Cavalry, as acting engineer officer of the district of New Mexico, will give an opportunity to instruct and enforce the attention required in that district.

General Order No. 10, Camp Supply, Headquarters Department of the Missouri, "informs post commanders that any failure relative to the taking of *topographical notes*, &c., will lead to an immediate change in the post commanders thus neglecting to perform the duty assigned them."

No additional surveys of posts and reservations have been made this year, except the running over of the old lines of the reservation of Fort Stanton, New Mexico.

During September, 1871, the difference of longitude between Detroit, Michigan, and Fort Leavenworth, Kansas, was determined and made the matter of a special report to the Chief of Engineers.

Maps have been distributed through the department, when needed, during the year, as follows:

	Sheets.
Map of Kansas	[illegible]
Jackson's map of Kansas	[illegible]

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	Sections.
Jackson's map of Indian Territory	3
Engineer Bureau, New Mexico and Arizona	2
Merrill's Colorado and Utah	12
Incidentals and tracings	41
Total	569

The expenditures of the office for the year, paid out of the appropriation for surveys for military defenses, were $5,485.

Since July 1, my report should include as part of the operations of the present season the continuance of scouting journals as the prominent point. These are as indicated, and promise to be more successful this year.

A surveying party, consisting of two principal assistants and two recorders, escorted by a detachment of thirty men, left Fort Wallace, on August 5, to examine and locate the headwaters of the Republican River, in the vicinity and above the forks of that stream. They will be absent about six weeks or two months.

The contemplated reconnaissance in the Ute country is at present in abeyance. The cavalry of the district of New Mexico are at present all in active service, and probably will be until October 1. The commanding officer of the district informs me that by that time steps may be taken to make a commencement, the work to be finished in the spring.

Permission has been received to use the Western Union Telegraph lines in the determination of the longitude of Fort Hays, Denver, and Santa Fé, and arrangements are being made for an early attempt at the work.

The amount available July 1, 1872, for the fiscal year ending June 30, 1873, is as follows:

Office expenses	$6,000
Longitude determinations	555
Reconnaissance in Ute country	4,516
Reconnaissance north of Fort Wallace	1,300
Total	12,371

In making estimates for this office it is difficult to make specifications for a year in advance. The ordinary office expenses should be met, and a fund should, I think, be on hand in case of sudden movements taking place. My own plan of operations would be to watch the movements of troops, and whenever they proceed where the country is unknown, to furnish the column with a civil surveyor, of practice and ability, and whose whole time being given exclusively to this could map the country thoroughly. I have found it impossible to judge beforehand where troops were liable to be sent, and so have lost much by not being able to estimate beforehand. Did I have at my disposal a certain sum to be expended only under these general directions, I could apply it on an emergency and produce good results. The expedition on the Staked Plains is a good example. Starting suddenly I had no time to request permission to apply any of my funds to it after having estimated for another quarter. I should have liked to provide means for an accurate examination. I have, however, made an estimate with this view and plan for the next year, and hope it will meet the approval of the Chief of Engineers.

I am, sir, very respectfully, your obedient servant,

E. H. RUFFNER,
First Lieutenant of Engineers.

The CHIEF OF ENGINEERS, *United States Army.*

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APPENDIX D D.

REPORT OF LIEUTENANT G. M. WHEELER, CORPS OF ENGINEERS, OF EXPLORATIONS AND SURVEYS IN NEVADA, UTAH, AND ARIZONA.

ENGINEER OFFICE,
EXPLORATIONS WEST OF THE ONE HUNDREDTH MERIDIAN,
Rendezvous Camp near Salt Lake City, Utah, July 13, 1872.

GENERAL: I have the honor to forward herewith an annual report of operations at "surveys and operations in Nevada and Arizona," for the fiscal year ended June 30, 1872.

At the commencement of the fiscal year the expedition for 1871 was in rendezvous camp near Belmont, Nevada. Examinations by the different parties were continued over extensive areas in Nevada, California, Utah, and Arizona, terminating, about December 11, in Tucson, Arizona, at which point the expedition was disbanded. Such officers and civilians as were necessary proceeded, via San Francisco, to Washington, D. C., to compile the maps and other data necessary for the expression of the results from the exploration. On account of the long distance, indirectness of communication, and especially the snow blockade upon the Union Pacific Railroad, the party could not reach its destination until late in January, 1872, at which time the office labors were commenced and vigorously prosecuted. Although large quantities of records of observations, collections, &c., did not arrive until late in May, it was still found possible to prepare a preliminary map of the area surveyed, and present early in March a preliminary report explaining the main features of the results and showing the progress of the work planned for the season. At the time of departure for the field the present year, the report was in the hands of the Government Printer, and its publication nearly completed.

The preliminary report, embracing, as it does, appendices furnished by Lieutenant D. W. Lockwood, Corps of Engineers, and Lieutenant D. A. Lyle, Second Artillery, and also by two of the civilian assistants, presents in skeleton the character of the work in that stage of its prosecution, with evidence favorable to the continuance, on a larger and improved scale, of surveys in our western country, to be prosecuted under the auspices of the War Department, as well as a general plan for these surveys, accompanied by an estimate of the funds necessary for the coming fiscal year.

After the forwarding of this report to the Department, the office work was carried on continuously, and certain preliminary steps were taken for the organization of the expedition of the present year. The office-work has embraced the necessary astronomical and meterological computations of the observations taken at the main and intermediate stations, the entire compilation of the topographical notes of the very large area examined, and the writing up of the geological report. All the collections in natural history were forwarded to the Smithsonian Institution, and will be examined by scientists of known reputation and ability. A report upon the minerals has been presented by Dr. W. J. Hoffman, who accompanied the expedition in the capacity of naturalist and mineralogist. The results of the entire season's work, though yet somewhat incomplete, may, in a short time after our return from the field the coming winter, be presented in full, with the exception of the final maps, which will require a longer period.

In the month of June a project was submitted to the Department

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for the operations of the present field season, embracing the establishment of certain astronomical points outside of the field-work, which covers areas in Southern and Southwestern Utah, Eastern and Southeastern Nevada, and Northern and Northwestern Arizona. The basins along our routes are those of a portion of the Great Salt Lake, Sevier, and Preuss Lakes, and certain parts of the valley of the Colorado, among the lower of the Grand Cañons. It is expected that other local basins, inferior in size, will be discovered. The expedition makes its first rendezvous at or near Salt Lake City, Utah, and is fully fitted for systematic work, however severe the campaign may be.

The main astronomical points mentioned in the project submitted comprise three within the field of the survey, and the following upon the Union Pacific and Central Pacific Railroads: 1st, near Julesburg, Union Pacific Railroad; 2d, Cheyenne, Wyoming; 3d, Laramie City, Wyoming; 4th, Fort Steel, Wyoming; 5th, the crossing of the Union Pacific Railroad and the western boundary of Wyoming; 6th, Winnemucca, on Central Pacific Railroad; 7th, the crossing of the Central Pacific Railroad and the one hundred and twentieth meridian. The telegraphic signals for the longitude determinations will be sent to the Mormon Observatory, at Salt Lake City, where an astronomical party will be stationed during the entire season. Should the plan proposed be prosecuted to its completion during the present or a subsequent season, some location not far from Sherman, or near the highest point on the Union Pacific Railroad, will be selected for a permanent observatory, in order that connections may be made with the points selected which shall have been reached by the telegraph in the large areas west of the one hundreth meridian, yet to be examined instrumen ally. The principal value of the astronomical stations, in the prosecution of geographical explorations and for other purposes, receives notice in my project, lately presented to the Chief of Engineers, which also embraces the systematic construction of a series of atlas-maps, upon a scale of 1 inch to 8 miles, covering the entire area and requiring about 85 sheets for the series, the greater part of 13 of which will have been covered by the surveys prosecuted under my charge up to the close of this season; the ensuing winter will admit of the publication of a portion at least of this number.

OPERATIONS THAT MAY BE ACCOMPLISHED DURING THE FISCAL YEAR ENDING JUNE 30, 1873.

The expedition for the season, engaged for the greater part of the time in Utah, will conclude its duties prior to the setting in of the winter and repair to Washington, to resume the large amount of office duties that will have accumulated, reaching that point as early as possible in December, so that more time may be at our disposal for the full collation of results, and allowing, at the same time, an earlier preliminary organization for the resumption of field labor in the spring of 1873. The attention of the Department and Congress has already been called both to the necessity and the desirability of the continuance of geographical exploration in the field of our western territory. In this connection it would seem that no Department of the Government has facilities for the prosecution of this work equal to those of the War Department, which, since the administration of President Jefferson, who sent out Lewis and Clark—men prominent among our country's explorers—has been intrusted with these duties, as a charge either related to the war measures, required during the early occupation of an unknown and inhospitable region, or, as in the later days, while peace prevails in co-operation with the national and industrial interests, due to the development of these sections of our territory.

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Subject to the approval of the Department, it is deemed proper to urge the continuance of this work, and that hereafter more especial attention shall be directed to the elaboration of the astronomical portion. Combining the requirements of interest and economy, it seems proper that an appropriation of $90,000 for the coming year should be requested at the hands of Congress.

The general character of the expenditures from this amount is indicated as follows:

Expense of civilian assistants in the field	$12,305 00	
Expense of civilian employés in the field	13,620 00	
Expense of civilian assistants in the field-office	9,075 00	
		$35,000 00
Transportation, including purchase of animals	8,000 00	
Forage for animals	10,000 00	
Purchase of material and incidentals	3,500 00	
Transportation of civilian assistants	3,250 00	
Transportation of material and specimens	1,500 00	
Subsistence of civilian assistants	3,500 00	
Add for contingencies	5,250 00	
		35,000 00
Expense of astronomical observers in the field	6,825 00	
Expense of meteorological observers in the field	2,100 00	
Expense of civilian employés, observers in the field	1,365 00	
		10,290 00
Expense of astronomical computers in the field-office	2,625 00	
Expense of assistant astronomical and meteorological computers in the field-office	1,875 00	
Probable expense erecting monuments, stations, &c	800 00	
Expenses for telegraphing	500 00	
Subsistence of astronomical party in field	1,200 00	
Transportation of instruments and material	750 00	
Transportation of assistants	1,000 00	
Add for contingencies	960 00	
		9,710 00
Total		90,000 00
Amount of funds in my hand June 30, 1872		$15,000 00
Amount of appropriation for the fiscal year ending June 30, 1873		75,000 00
Amount asked for fiscal year ending June 30, 1874		90,000 00

All of which is respectfully submitted.

GEORGE M. WHEELER,
First Lieutenant, Corps of Engineers, in charge.

The CHIEF OF ENGINEERS,
United States Army, Washington, D. C.

APPENDIX E E.

REPORT OF THE SUTRO TUNNEL COMMISSION.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 4, 1872.

SIR: I transmit herewith the report and accompanying papers of the commission appointed under the authority of the act of Congress approved April 4, 1871, "to examine and report upon the Sutro Tunnel in the State of Nevada, authorized to be constructed by an act of Congress approved July 25, 1866, with special reference to the importance, feasibility, cost, and time required to construct the same; the value of the bullion extracted from mines on the Comstock lode; their present and probable future production; also, the geological and practica

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value of said tunnel as an exploring work, and its general bearing upon our mining and other national interests in ascertaining the practicability of deep mining."

The report presents the views of the commission briefly and clearly.

Under the head of *importance of the tunnel*, the commission is of the opinion that the tunnel is not a necessity for ventilation or drainage, but that any scheme which promises increased economy in working the mines and rendering valuable the vast amount of now worthless low-grade ores in the Comstock lode becomes of national importance. Whether the Sutro Tunnel project fulfills this condition of economy depends, in the opinion of the commission, upon the practicability of securing a sufficient water-power from the Carson River, at all seasons, for the reduction of the ores, and upon the efficacy of the methods employed in Germany and other countries in Europe for the concentration of ores. On the first point the commission has no doubt. On the second it has not been able to obtain the desired information.

On the *feasibility of the tunnel*, the opinion of the commission is in favor of the entire feasibility of the project, so far as its construction is concerned.

The *cost of the tunnel*, the branch and all the shafts, is estimated at $4,418,329.50 in gold.

The *time of completion* is estimated at three and one-half years, which may be reduced to two and one-third years, if machinery be judiciously employed.

The *value of the bullion* extracted from the mines of the Comstock lode, according to the information the commission was able to gather, is $125,000,000.

The *present annual production* the commission places at $15,000,000.

As regards *the probable future yield*, the commission says:

No claim can be made to anything like accuracy, except in the few instances in which ore-bodies are now developed. The commission has already stated its belief in the lode being what is known as a true fissure-vein, or as continuing downward indefinitely in the crust of the earth; but whether the vein will continue to be ore-bearing cannot be predicted with any degree of certainty. It is a matter of opinion, to be based, however, upon probabilities and the actual results experienced in deep mining in other parts of the world. These, in the judgment of the commission, favor the finding of ore down to the lowest depths that can be reached; and that this opinion is shared by most of the mining authorities seems to be shown by their continued downward search.

The report concludes with the opinion that, as an exploring work for deep mining, the Sutro Tunnel may justly claim favorable consideration.

The information to be obtained from an examination by a commission of the methods followed in the mines of Germany and England appears to be of such importance as to recommend itself to the favorable consideration of Congress.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

The Hon. the SECRETARY OF WAR.

OFFICE SUTRO TUNNEL COMMISSION,
New York, December 1, 1871.

GENERAL: I have the honor to forward herewith the report of the Sutro Tunnel commission, and in separate packages the following:

Package containing maps, plans, and drawings, marked from 1 to 11, inclusive.

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Package containing estimate, circular letter, reports of superintendents of mining companies, &c., marked from A to L, inclusive.

The special information asked for by Mr. Sutro was received in time to be used in making the report; but the paper which he was requested to furnish, inasmuch as the opponents of the project had been invited to do the same, has not come to hand. It may be expected daily, and when received will be forwarded with request that it be added to the papers accompanying the report.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Lieutenant-Colonel of Engineers, Brevet Major-General,
Senior Officer of Commission.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

OFFICE SUTRO TUNNEL COMMISSION,
New York, November 30, 1871.

GENERAL: The commission appointed under the authority of the act of Congress approved April 4, 1871, "to examine and report upon the Sutro Tunnel in the State of Nevada," having completed the duties assigned to it under said act, has the honor to submit the following report:

The members of the commission met in this city, in pursuance of your instructions, on the 9th of June, and after organizing and making the necessary preliminary arrangements, including a visit to and examination of the Hoosac Tunnel in Massachusetts, proceeded to Nevada, arriving at Virginia City on the 29th of that month, and at once entered upon the duties with which they were charged. From that date to the 7th of August the commission was constantly occupied with its investigations, during which period it examined pretty thoroughly the mines on the Comstock and other lodes in the vicinity, the country in the neighborhood within a general radius of fifteen miles, with a view to ascertaining its topographical and geological character, and conferred with the mining authorities, miners, and others interested in the great and almost sole industrial interest of that section of Nevada.

Every facility was afforded the commission by the mining authorities and the people generally; the desire seeming to be on all hands to give the opportunity for a full and complete investigation of a subject in which the entire community was so deeply interested. To the superintendents of the various mines the commission is especially indebted for the large mass of information afforded by them, both verbally and in writing, in relation to the mines under their control. The latter portion will be found in their reports in the appendix, made in response to the interrogatories of the commission, a copy of which is also appended. To those papers frequent reference will be made in the course of this report. Mr. Sutro, the projector of the tunnel, was also present during most of the time the commission was in Nevada, and was always ready to afford information, and, from his familiarity with the subject, to suggest ready means for obtaining information from other sources.

The duties of the commission, as prescribed by the law under which it was appointed, were, "to examine and report upon the Sutro Tunnel in the State of Nevada, authorized to be constructed by an act of Congress approved July 25, 1866, with special reference to the importance, feasibility, cost, and time required to construct the same; the value of the bullion extracted from the mines on the Comstock lode; their present and probable future production; also, the geological and practical value of said tunnel as an exploring work, and its general bearing upon our

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mining and other national interests in ascertaining the practicability of deep mining."

To the above points the investigations of the commission, although naturally embracing a wide range, were particularly directed, and to them this report will be strictly confined, treating of them in the order in which they are given in the act above quoted.

IMPORTANCE OF THE TUNNEL.

In treating of the importance of this work, it seems proper to give a brief general description of the Comstock lode, referring for an account of its geological character to that part of the report which treats of the "geological and practical value of said tunnel as an exploring work."

The term *lode* is applied to "any regular vein, whether metallic or not, but commonly to a metallic vein," and will in this report be considered as applying to that fissure in Nevada which traverses Virginia City and Gold Hill, and is generally known as the "Comstock." This fissure or rent in the earth has an extent not yet fully developed, but which reaches certainly from the Ophir mine on the north to the Uncle Sam and Overman on the south, a distance of 12,000 feet. Beyond these points the lode is supposed to extend to the north and south to the Seven-mile Cañon in the former direction, and to the American Flat in the latter. It may, therefore, be said that while the fissure itself is believed to have been traced from the diggings known as the Utah mines on the north to the locality known as the American Flat or "American City" on the south, a length of about 22,000 feet, yet the portion of the lode now worked is comprised between the Ophir on the north and Overman on the south, or a distance of about 12,000 feet, or, say, two and one-quarter miles. This portion of the lode may, as is usually done, be divided into three groups, the "Ophir," the "Gould & Curry," and the "Gold Hill." The two former may be considered as within the limits of Virginia City, the last being in the town of Gold Hill; the two towns being, however, so connected that the stranger is at a loss to determine where one ends and the other commences. Both of these towns rest absolutely upon the lode, and the mine-shafts rise directly in the midst of the streets and houses. The lode has a dip or angle of inclination to the east of about 45°, varying in either direction some 10°. This variation, as might be expected, often occurs within small limits of extent of the vein, but generally keeps within those of 38° and 55° of inclination to the horizon.

The croppings or surface indications of the lode are generally west of the towns of Virginia City and Gold Hill, which, as before remarked, are in most part over the workings of the lode.

In the earlier days of mining upon the Comstock, the work was prosecuted to some extent by means of adits or horizontal tunnels; but as depth was attained, this process was necessarily abandoned owing to the configuration of the country immediately about it, and working by means of vertical shafts was exclusively followed. All the mines of the lode now worked are operated in this manner—that is, a vertical shaft is sunk in the "east country" rock, which, at a depth that can be pretty closely estimated, will reach the lode, and after passing through it into the "west country" rock, is generally continued in the latter upon an angle corresponding with the inclination of the west wall at the point of junction. From these shafts at various depths or "levels," usually about 100 feet apart, drifts or small tunnels are run horizontally in various directions through the lode to ascertain its ore-bearing char-

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acter; and through them the ore and débris are brought to the shafts and raised to the surface by steam-power. The water met with in the workings is pumped to the surface through these shafts by the agency of the steam machinery, and air for ventilation is forced by blowers down the shafts, through wooden boxes, and distributed through pipes to the various working headings.

The ore thus brought to the surface is taken from the "dumps" on which it is first deposited, by wagons or railway-cars, and transported to the mills for reduction. These mills are scattered over the country wherever water is to be found, the greatest distance being about eighteen miles. With the exception of those on the Carson River, which are run by water-power, these mills are worked by steam; the water to be obtained being sufficient for the purposes of reduction only, and not for power. Indeed many of these steam-mills were idle during our visit, for the want of water, and the water-mills on the Carson River were generally working up to a part only of their capacities for the same reason.

In the early days of mining on the Comstock lode, several excellent wagon-roads of easy grades were constructed, leading to the mill-sites and to the sources of supply of the lumber and the fuel needed in the working of the mines; but these are now in a great degree supplanted by a railroad recently constructed from Virginia City to Carson City, passing through Gold Hill, and having branches leading to the principal reduction-works. By this road a large part of the ore extracted from the mines is transported to the mills, and most of the lumber and wood used for mining purposes is brought back on the return trips. This road, which is a fine example of railway engineering over a difficult country, is about twenty-two miles in length, not including its branches, and is reported to have cost about $2,000,000. It is about to be connected with Reno, a station on the Central Pacific Railroad, by an extension from Carson City to the latter point, but at the time of our visit its principal business was the transportation of ore from the mines to the mills, and of lumber and fuel for the supply of the mines.

One of the objects of the tunnel, as will be seen further on, is to change almost wholly the mode of working the mines just described. The tunnel, which is to be nearly rectangular in cross-section, having a height of 12 feet, with a width at bottom of 14 feet, and at top of 11 feet, commences at a point in the valley of the Carson River, and running in a direction nearly perpendicular to the Comstock ledge, is to intersect it at a level of 1,898½ feet below the point of the croppings marked A on the map, to which the various levels of the mines are referred. At or near this point of intersection a cross-tunnel of similar dimensions is to run along the ledge, and to communicate with all the mines. A commencement of 70 feet only in length has been made on the main tunnel, more with a view to showing what is designed than for any other purpose, and a drift six feet by seven in cross section had been extended under the intervening mountains about 2,300 feet at the time of our visit. It is understood that this length had been increased to 2,530 feet on the 14th of November. The map No. 1, herewith, of the country in the vicinity of the Comstock, shows the positions and directions of the main and cross tunnels, and the sheet marked No. 2, a section and profile of the grounds on the line of the tunnel. The cross section of the tunnel and of the drift or preliminary tunnel, upon which work is at present prosecuted, are shown on sheet marked No. 3. The length of the main tunnel will be 19,790 feet, or about three and three quarter miles, and the cross tunnel, if extended only so far as to include

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the mines now being worked, about 12,000 feet, or about two and one-quarter miles. Should the ledge north of the Ophir and south of the Uncle Sam and Overman be again worked, the cross-tunnel must be increased in length correspondingly. In our estimates of costs we have considered the main and cross tunnels separately, and have restricted the latter to the limits of the Ophir on the north and the Uncle Sam and Overman on the south. Drawings exhibiting plans of all the mines within the above limits will be found with this report, marked 4, 5, 6, 7, 8, 9, 10, and 11.

The principal advantages of the proposed tunnel in relation to the mines, as claimed by Mr. Sutro, may be stated briefly as follows:

1st. The improved ventilation of the mines, resulting from the current of air which, entering the tunnel at its outer extremity, and passing through it and up into the mines and out at their present shafts, will so cool and purify the heated, stagnant atmosphere of the drifts and stopes as to preserve the health of the miner, and enable him to accomplish a greater amount of labor than would otherwise be possible.

2d. The drainage of the mines above the level of the tunnel—an object which is now accomplished by means of costly machinery and at great expense. On the connection of the tunnel with a mine, the water in the latter would discharge itself without the intervention of machinery and without cost.

3d. A largely increased economy in the working of the mines by taking the ore through the tunnel to reduction works at its mouth, instead of raising the same to the surface and transporting it, often to a much greater distance, to the mills now established.

4th. Its value as an exploring work in cutting at considerable depths several mineral veins or lodes known to exist to the eastward of the Comstock, all of which have been, and at some points continue to be, worked for the precious metals; also, in a geological point of view, in determining the depth at which precious ores will be found in our country in what may be considered as true fissure-veins.

These claims on the part of the advocates of the tunnel will be considered in the order in which they have been stated, with the exception of the last, which can be more properly treated under the head of "the practical value of said tunnel as an exploring work."

VENTILATION.

At the time the tunnel was projected, and the act of Congress of July 25, 1866, was passed, the mines on the Comstock lode were undoubtedly much embarrassed in their operations by the lack of proper ventilation. The atmosphere in their stopes and drifts was hot and stagnant, and any relief, such as was promised by the tunnel, might well be viewed as indispensable by the mining authorities and miners to the further prosecution of their search for the precious metals. A stagnant atmosphere and a temperature of over one hundred degrees might well occasion misgivings of success in their attempts upon the lower and therefore hotter levels. At that time each mine was worked independently of the others, upon its own ground, with its single shaft forming the only communication between its stopes and drifts and the surface. Without the aid of mechanical ventilation, it is not surprising that, at a depth of three or four hundred feet even, the air of the mines should have severely taxed the miner's powers, and induced the belief that further search into the heated bowels of the earth would be impossible,

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unless some artificial aid, such as the proposed tunnel promised to afford, should be provided.

But this very necessity for an improved and increased ventilation indicated one of the means by which it might, in a great degree at any rate, be accomplished. The drifts of contiguous mines were connected together, an air current was established down the shaft of one and up the other, passing in its transit through such of the drifts, stopes, and winzes as were between them, thus purifying and cooling the atmosphere in those parts of both. For the portions of the mines which were influenced imperfectly or not at all by the current of air thus established recourse was had to blowers operated by the steam-power employed in hoisting. By means of these blowers air could be forced through pipes to all parts of the mines not affected sufficiently by the natural ventilation established by the subterranean connection just alluded to. At the time of our visit, the mines were generally well ventilated, and the miners with whom we conversed did not complain; and in the case in which a more effective change of air was needed, steps were being taken to accomplish it.

It is, therefore, the opinion of the commission that, while the proposed tunnel would increase and improve the ventilation of the mines and possibly dispense with the use of some part of the means for artificial ventilation now employed, it is not a necessity for ventilation. Even with all the aid that the tunnel can be expected to afford, it is the opinion of the commission that mechanical ventilation by blowers, operated by steam or other power, would still be needed at the headings and in the stopes where the air from the tunnel would not penetrate.

According to natural laws as at present understood and received, the air entering the proposed tunnel would pass through it and up the shafts of the mines by the easiest and therefore by the most direct channels, thereby conferring little if any benefit upon the stopes and drifts not in the line of such direct transit. Hence the necessity which is assumed for a continuance of mechanical ventilation for certain portions of the mines after the completion of the tunnel.

And here it may be proper to allude to certain anomalies observed in the ventilation of the mines on the Comstock lode, as well as in mines upon lodes lying to the eastward. According to the received laws of ventilation it would have been assumed that, in the case of two shafts connected at bottom by drifts, the air current would pass down the lower and through the drifts up the higher, and that this rule would be without exception where not influenced by circumstances of situation or artificial causes; that, in the case of a long adit or tunnel, the inner extremity of which was connected with the surface by a shaft, the outer being directly upon the side of the mountain, the current would be through the tunnel and up the shaft. In the former case the current was found to be sometimes in one direction and sometimes in the other, it having been permanently changed in one instance, after the occurrence of a fire in one of the mines thus connected; the down-draught having been through the shorter shaft before the fire, and through the longer ever since. In the latter case, which applies to two tunnels visited by the commission, the down-draught was into and downward through the shafts and out of the tunnels in a very strongly perceptible current. In view, therefore, of these anomalies, it would seem uncertain whether the current of air would pass through the proposed tunnel into the mines and out through the shafts, or the reverse. So far as the ventilation is concerned, it will be of little importance which way the current should pass. Probably the mines would be the

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more benefited by its passing downward through them and out of the tunnel than in the reverse direction.

DRAINAGE.

In the early days of mining upon the Comstock, much trouble was experienced from water which accumulated in the mines, and occasioned the necessity for powerful and expensive machinery for drainage. When, therefore, the tunnel was proposed, it was looked upon as an important accessory to further mining operations in affording a ready and effective means of draining the ledge without the recourse to costly mechanical contrivances. It was then assumed, naturally enough, that the lower the depth the greater the amount of water to contend against, and serious doubts appear to have been entertained of the possibility of freeing the mines from water by mechanical means. The construction of the tunnel seemed, therefore, a necessity. But as greater depths were attained it was discovered that the water, instead of permeating the earth to an indefinite extent, was mainly confined to near the surface; that below a few hundred feet it was struck in limited quantities only. It was also discovered that this water, instead of being generally diffused, was collected in pockets bounded by impermeable seams of clay, which, when pierced, had only to be drained to exhaust the supply. As the mining operations have increased in depth, these pockets or reservoirs have become less frequent and formidable, till in many of the deepest the water is not only not troublesome, but is found in less quantity than is needed for the purposes of the mines themselves, thus necessitating the purchase of water from the company which furnishes the same to the inhabitants of Gold Hill and Virginia City, or from other and wetter mines. By reference to the statements of the superintendents, appended to this report, it will be seen that the cost of pumping for all the mines did not, probably, exceed $150,000 for the past year, and that in some of them there was no water at all. This sum exceeds that arrived at by the commission—viz, $124,674—which was obtained by taking the costs as given for the mines, so far as reported, and estimating for the others.

Taking, then, the observations of the commission in connection with the statements of the superintendents of the mining companies, we are of the opinion that the tunnel for this purpose alone is not a necessity for the drainage of the Comstock lode. That it will effectively drain all those with which it shall be connected is obvious; but the same result can be attained by present means at less cost—a cost which, moreover, promises to become still smaller as the mines progress in depth.

ECONOMY OF WORKING, ETC.

Under the present system of operating the mines, the ore and the refuse rock are raised to the surface through the shafts by steam-power, the ore being transported to the mills by wagons or by the railroad before alluded to, and the refuse rock deposited at the dumps contiguous to the shafts. The items of expense, as given by the superintendents, vary somewhat, as might have been expected, in view of the different circumstances in each. The average of certain of the more important of them may, however, be stated with sufficient accuracy, as follows:

Cost per ton of hoisting from depths varying from 1,250 to 1,750 feet, being the average reported for seven of the principal mines of the lode	$0 51.17
Cost of pumping for the year ending June 30, 1871, as arrived at by the commission, by taking the cost of the mines as far as reported and estimating for the rest	124,674 00

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The superintendent of the Ophir mine, a very intelligent man, estimates the total cost for pumping on the Comstock lode for the past year as not exceeding	$150,000 00

If we assume what appears from the reports and from other sources as an average yield of the mines—viz: 365,600 tons annually—the cost for certain items of expense by the present method of working will be as follows:

Hoisting 365,600 tons of pay ore, at 51.17 cents	$187,077 52
Transportation of same to mills, at $1 50	548,400 00
Pumping for last year, (commission's estimate)	124,674 00
Hoisting and lowering 3,000 miners, at 8 cents each way, or 16 cents each	175,000 00
Total	1,035,151 52

In the above statement the cost of hoisting the refuse rock from the drifts, winzes, &c., is not included, as the quantity is wholly indeterminate, being the greatest in those mines where prospecting alone is being carried on, and the least in those which are working upon ore bonanzas. Indeed, in the latter the amount of débris is inconsiderable. It would be of the highest importance to a full and accurate comparison of the cost of working the mines by the present method and by the tunnel, to introduce this item, as it is very considerable, and the expenditure per ton for hoisting it is the same as for ore; but this seems quite impossible, owing to the indefiniteness of the quantity of refuse removed from the mines.

In considering the cost of operating the mines by the tunnel, it must be stated that, under the provisions of the act of Congress approved July 26, 1866, the tunnel company is authorized to collect from all the companies mining upon the Comstock lode a royalty of $2 per ton for each and every ton of ore taken from the mines after the tunnel shall be connected with them, whether the tunnel be used by the mines or not: that a tariff of 25 cents per ton per mile (or such lesser sum as may be agreed upon) for the transportation through the tunnel may be established; also a charge of 25 cents each way for every man connected with the mines who is carried through the tunnel. The cost of working the mines through the tunnel, as compared with the same items as given above for working by the present method, may then be stated as follows:

Lowering 365,600 tons pay-ore to tunnel level, at 10 cents	$36,560 00
Transportation of same an average of five miles, at $1 25	457,000 00
Transportation of 3,000 workmen, at 50 cents=$1,500 per day	547,500 00
	1,041,060 00
To this should be added the royalty of $2 per ton, which for the average production of 365,600 will amount to	731,200 00
Which makes a total of	1,772,260 00

The item of drainage is not included in the above, as the tunnel will thoroughly drain all the mines connected with it without cost. This is not a favorable showing for the economy of working by the tunnel, but it should be stated that while the act of Congress authorizes the tunnel company to make a charge of 25 cents per ton per mile for transportation of ore, rock, débris, &c., it is claimed by Mr. Sutro that such transportation can be done profitably at 10 cents per ton, and that no higher tariff will be demanded. It is also understood that a similar diminution will be made in the charge for transportation of workmen

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Such reductions in tariff would make a material change in the estimate given above, which would then stand as follows:

Lowering 365,600 tons pay-ore to tunnel level, at 10 cents	$36,560
Transportation of same an average of five miles, at 50 cents	182,800
Transportation of 3,000 workmen at 20 cents, or $600 per day	219,000
	438,360
Royalty on 365,600 tons ore, at $2	731,200
Total	1,169,560

Even with this reduction in tariff, the balance would be against working through the tunnel when the royalty, which is the most important item, is included, (at lower levels the comparison would be more favorable;) and were there no other considerations to be taken into account, the opinion of the commission would necessarily be against the tunnel in the point of economy of operating the mines.

Before presenting these other considerations it should be stated that not one of the superintendents of mines has expressed himself in favor of a change in the present mode of working; and that some of them have given the opinion, in effect, that should the tunnel, when completed, with all its drifts and branches, be offered free of charge, not one mine on the Comstock would be operated through it, for the reason that the present mode of working would be cheaper and more expeditious. This opinion is, no doubt, founded upon the supposition, as it is indeed stated in one of these reports, that the ore taken through the tunnel to its mouth is afterward to be transported to the present mills, thereby involving a cost for transportation about equal, perhaps, to what is now paid for carrying the ore from the mouths of the shafts to the mills. Were the present mills to be employed for the reduction of the ore brought out through the proposed tunnel, this opinion would, no doubt, be correct, and the tunnel project would have to be condemned. But it is a part, and an essential part, too, of the scheme to have reduction works at the mouth of the tunnel, to be operated by the water-power of the Carson River, by which the cost of the further transportation of the ore alluded to above will be saved. This plan, which is one of the considerations to which we have referred, would involve the suppression of the present mills, or at any rate such of them as now draw their supplies of ores from mines which would use the tunnel, and also seriously injure financially the railroad leading to Carson City, which was built for, and mainly depends upon, the carrying of the ores to the reduction works. So far as the milling interests are concerned this would be of comparatively small consequence, and the machinery requires renewal in large part every two or three years, and the mills would be maintained in the interval with a view to their abandonment on the completion of the tunnel or to the transfer of their machinery to new sites at its mouth. To the railroad, however, the results would be more injurious, as the interests outside of the transportation of ore, timber, and other supplies for the mines, would probably not be sufficient for its maintenance. How far these injuries to vested interests should influence action in regard to the construction of the proposed tunnel, is not for the commission to determine. It is clear, however, that the successful working of the tunnel would have an effect upon the railroad similar to that which the latter has produced upon the very excellent and costly wagon-roads which were constructed to facilitate transportation in the earlier days of mining upon the Comstock.

As has been stated, the tunnel project includes, as an important and,

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indeed, inseparable adjunct, the establishment of mills at its mouth for the reduction of the ore; and in order that these should be separated cheaply and successfully, a sufficiency of water-power is necessary. Water, to some extent, may be counted upon from the drainage through the tunnel, a quantity sufficient, perhaps, for purposes other than motive power, but not for running the mills, the power for which, supposing water only is to be used, is to be had from the Carson River alone.

This stream, which has its sources in the Sierra Nevada Mountains and is fed almost entirely from its melting snows, is not at all times to be depended upon in its natural condition for a supply of power. Aid is here necessary in aid of nature. At certain seasons of the year the river becomes a rushing torrent, overflowing its banks and covering its valley opposite the mouth of the tunnel for a considerable extent; at others, it is reduced to a comparatively insignificant rivulet. When the commission was in Nevada, it was represented to be at about its lowest stage, and all its water, when led into the flumes, was insufficient to run the mills established along its valley to their full capacity.

In carrying out fully that part of the project which requires the establishment of mills at the mouth of the tunnel, it will, therefore, be necessary to secure by artificial aid an adequate supply of water for running them at all seasons of the year—at those times in which the flow is insufficient, as well as those in which the supply is far beyond what is necessary. This, it is believed, may be accomplished by the construction of a high dam across a narrow gorge of the Carson River some five miles above the mouth of the tunnel, which, by damming back its waters, shall form a lake or reservoir that will afford a supply during all seasons of the year, for operating all the mills required for reduction of the ore which can be taken from the Comstock and from the other lodes which may be intersected by the tunnel. That this can be accomplished, the commission does not entertain a doubt; yet it should be understood that this opinion is based upon observation alone, and not upon its actual survey. It should be here stated, by way of explanation of the reasons why the commission did not institute surveys for ascertaining exactly all the points involved in this connection, was that it did not come within the original project of the Sutro Tunnel scheme, and its importance was not so clearly seen while the commission was in Nevada, as it is at the writing of this report, when the various data upon which many of its conclusions are founded, have been fully examined and compared. The opinion we have expressed is, however, borne out by the rather imperfect examinations made since our visit by the tunnel company, through the agency of the surveyor general of Nevada. The commission is, however, of the belief that his results are less favorable to the project than a more detailed survey would have shown. The report of the surveyor general, furnished by the tunnel company to the commission, will be found in Appendix J.

But should the foregoing be practicable, it still seems necessary to the economical working by the tunnel, as against the present mode of operating the mines, that an improved system of concentration of ores should be established. It is claimed by the advocates of the tunnel that, with an abundant supply of water, concentration works may be put up after the methods followed in the mining regions of Germany and England, by which the refuse matter may be mechanically separated from the valuable ores, so that only one ton in fifty, perhaps, need be subjected to the process of reduction for securing the precious metals. According to the accounts received of the workings of the German mines, ores assaying less than $5 per ton are mined with profit, and that

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in the English mines, in Cornwall, one is worked which produces only three ounces of silver, or say $3 90 per ton of ore, and two others which yield six ounces and ten ounces respectively, and all at a profit, through improved methods of concentration. The commission has exercised much diligence toward ascertaining the actual facts in regard to these statements, as they are of the highest importance in connection with the question under consideration; and it has visited the Passaic mine, at Franklin, New Jersey, and the Lehigh mine, near Bethlehem, Pennsylvania, where machines, claimed to be constructed after the models employed in Germany and England, are used in the concentration of the ores of zinc, but has found nothing that is applicable to the concentration of the ores of the Comstock lode.

The loss of precious metals in the reduction by the German and English methods is represented to be not exceeding 5 per cent., while in Nevada it is not far from 35 per cent. in milling, with a saving of perhaps 10 per cent. more in the subsequent workings of the tailings and slimes, making less than 75 per cent. in all. The actual loss in reduction, therefore, appears to be more than 25 per cent., which for a production of $15,000,000 per annum, entails a loss of the precious metals exceeding five millions of dollars, or a loss beyond what would result from the methods referred to, by which 95 per cent. is saved, of at least four millions of dollars annually.

It would appear to be very singular that this saving should not be made in the working of the most important mines in our country, if the statements just referred to are reliable. But it is denied by some of the mining authorities upon the Comstock that this statement is correct, and it was asserted that large sums had been offered in vain for producing like results. Indeed it seems quite impossible, from the information we have been able to obtain, to speak positive upon the subject. A personal examination of the foreign mines referred to by one or more competent individuals is the only sure mode of ascertaining the actual facts, as applicable to the treatment of the ores of the Comstock. Yet some better mode of reduction than is now practiced in Nevada may undoubtedly be devised, which shall secure a part at least of the large amount now lost in the separation of the precious ores from the refuse matter.

Still another consideration appeals strongly for this economy in the working of the ores—in the saving of a large percentage of metal now lost in reduction. Of the bodies of ore, other than those of low grade, now known to exist in the Comstock, the greater part will be worked out before the tunnel will be completed. Whether other bodies will be discovered is a matter of conjecture. That the lode is a true fissure vein is, in the opinion of the commission, beyond question. But whether the vein will continue to be metal-bearing to indefinite depths cannot be stated with any degree of certainty, though, in the opinion of the commission, the weight of reasoning and the experience in mining in other parts of the world largely favor such continuance. But, supposing that no further deposits of the precious metals should be discovered, the tunnel, if constructed, would have to depend upon the working of the large bodies of low-grade ores, which have thus far been passed over as unprofitable under the present expensive system of mining and reduction. That such ores exist in large quantities in the mines, containing from eight or ten to twenty-five dollars per ton, is generally admitted, and seems to be undeniable. Only one of the mining superintendents with whom we conferred doubted this, and his opinion, we are satisfied from other testimony, is erroneous. Ores milling less

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than about $20 per ton, or assaying less than about $30, cannot be mined with profit under the present imperfect process of reduction and the high price of labor which prevails in the mining districts of Nevada. Economy must, therefore, be sought for before the immense amount of low-grade ores can be profitably worked; and this economy is to be found in improved modes of reducing the ores, including concentration, in the general application of water-power, and in the more general substitution of machinery for manual labor, rather than in a reduction of the present rates of wages. A saving of 95 per cent. of the gold and silver contained in the ore, as is asserted to be the case in the German mines of similar character to the Comstock, would go far toward giving value to the millions contained in the low-grade ores which have been thrown aside or passed over as worthless. While it is not assumed that mining can be carried on as cheaply here as in Europe, owing to the higher value of labor in our country, it is not seen why, in other respects the cost to us should be greater, provided we adopt the same or improved means in the reduction of the ores. If, therefore, ores assaying but $5 per ton can be there mined and reduced at a profit, we do not see why ores of the same character assaying $10 may not be profitably worked with us, with our higher rates of labor. This would render valuable the vast amount of now worthless low-grade ores in the Comstock, and add millions to the world's circulation. Hence the importance to the nation of any scheme which promises increased economy in the working of mines.

Whether the Sutro Tunnel project fulfils this condition of economy depends, in the opinion of the commission, upon the practicability of securing a sufficient water-power from the Carson River, at all seasons, for the reduction of the ores, the possibility of which, though not fully proved by accurate surveys, no doubt is entertained, and upon the efficacy of the methods employed in Germany and other countries of Europe for the concentration of ores, of which we are unable to vouch.

Assuming the correctness of these two points, of abundant water and of concentration of ores, we would express an opinion favorable to the tunnel and its accessories as an economical mode of working the mines of the Comstock; otherwise, we should advise that the mines continue to be operated as at present practiced.

FEASIBILITY OF THE TUNNEL.

Of the practicability of the project there is no doubt. It is a question of cost alone. So many tunnels have been run in this, as well as in other countries, through material much more difficult, that no reasonable grounds exist for questioning the feasibility of the one we are considering. So far as surface indications are to be relied upon, the rocks to be penetrated do not differ materially from those which are met with in the operations on the Comstock, in the shafts, drifts, and winzes which have been opened in those mines in the search for the precious metals. While it is quite impossible to predict with any degree of certainty exactly what kinds of rock will be met with in the progress of the tunnel, or in what proportions, it is safe to assume that nothing will be encountered which will offer any serious obstacle to the miner. We, therefore, dismiss this portion of the investigation with the expression of the opinion of the commission in favor of the entire feasibility of the tunnel project, so far as its construction is concerned.

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COST OF THE TUNNEL.

In making the estimate of cost, the commission has been governed mainly by costs of shafts and drifts in the mines on the Comstock, and by the actual expenditures as reported by the tunnel company in running its preliminary tunnel or drift, which, as has been stated, has already penetrated over 2,500 feet under the mountains lying between its mouth and the lode. Taking all these elements of information into consideration, an average of cost per foot of length has been deduced, which, in the judgment of the commission, is as reliable as any that can be arrived at for an estimate for a tunnel which is to run for so great a length through rocks, the character of which can only be judged of, and then only imperfectly, by surface indications. This cost, which is given for the main tunnel and its shafts separately from that of the cross or branch tunnel, is:

For the main tunnel and four shafts	$2,707,595 15
For the branch tunnel and two shafts	1,710,734 35
Total in gold	4,418,329 50

This estimate, the details of which are given in the appendix, embraces all the expenditures supposed to be necessary for the completion of the work, including machinery, fuel, shelter, superintendence, &c. It is but proper to remark, however, that its correctness will depend in a large degree upon the character of rock met with, and may be either too large or too small as the difficulties shall be found to exceed or fall short of the supposition upon which the estimate is based. The prices stated are in gold, which is the only basis of value recognized in Nevada.

TIME REQUIRED FOR THE CONSTRUCTION OF THE TUNNEL.

Our estimates are based upon the progress made in the shafts and drifts in the mines of the Comstock lode, and also upon the actual progress in the construction of the preliminary tunnel so far as it has been prosecuted, all of which have been executed by manual labor. Under this supposition of progress it will require 1,186 days, or about three and one-fourth years, for the completion of the main tunnel after the work shall have been fairly commenced at all the shafts; and if the cross or branch tunnel be commenced at the same time, as it may be, and pushed forward correspondingly, the whole may be completed in nearly the same time; that is, in about three and four-tenths years after vigorous operations shall have been undertaken upon all parts. But if machinery be judiciously employed, there seems to be no doubt that the tunnel may be completed in two and three-tenths years. Considerable attention has been given to the subject of the application of machinery to this object, resulting in the conviction that the time needed for the completion of the tunnel, beyond what would be required if manual labor alone were employed, may, by its use, be shortened at least one-third.

THE VALUE OF THE BULLION EXTRACTED FROM THE MINES ON THE COMSTOCK LODE.

To ascertain with perfect accuracy the total value of the bullion extracted from the mines of this lode is quite impossible, owing to the almost total absence of records during the early days of mining. The

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commission has, however, obtained a statement of the bullion sent by express, by which it has been mainly transported, amounting for the ten years from 1861 to 1870, both inclusive, to $123,607,278; and it is the opinion, of those well informed upon the subject, that the product of the mines previously to 1861, including bullion taken away by private parties, will swell the total production, from 1859 to 1871, to $125,000,000.

PRESENT AND PROBABLE FUTURE PRODUCTION.

The mines which are now productive are given below, with the amount of bullion for the last year so far as ascertained; all the other mines on the ledge being engaged in prospecting only:

1. Savage	$818,216 50
2. Hale & Norcross	1,632,500 [illegible]
3. Chollar Potosi	3,455,423 [illegible]
4. Yellow Jacket	2,000,000 [illegible]
5. Kentuck	Not reported.
6. Crown Point	Do.
7. Belcher	Do.

The present annual production may, it is believed, be taken with sufficent accuracy at $15,000,000.

As regards the probable future yield, no claim can be made to anything like accuracy, except in the few instances in which ore-bodies are now developed. The commission has already stated its belief in the lode being what is known as a true fissure vein, or as continuing downward indefinitely in the crust of the earth; but whether the vein will continue to be ore-bearing cannot be predicted with any degree of certainty. It is a matter of opinion, to be based, however, upon probabilities and the actual results experienced in deep mining in other parts of the world. These, in the judgment of the commission, favor the finding of ore down to the lowest depths that can be reached; and that this opinion is shared by most of the mining authorities seems to be shown by their continued downward search.

Some few of the mines, as the Crown Point, Belcher, Hale & Norcross, and Yellow Jacket, have ore enough in sight to occupy them for three or four years to come; others, like the Savage, will exhaust all known bodies in a shorter time, while others still will have to depend for their future upon the success of the prospecting in which they are engaged, or upon the low-grade ores which have been passed over or thrown aside as not paying for the cost of working; this last involving the necessity for a large economy beyond what is now practiced in the working of the mines and in the transportation and reduction of the ores.

ON THE "GEOLOGICAL AND PRACTICAL VALUE" OF THE SUTRO TUNNEL "AS AN EXPLORING WORK."

In view of the limitations contained in the law, the commissioners confined their geological investigations to the line of the tunnel and its immediate vicinity.

To the works of Baron Richthofen, who devoted many months to a careful examination of the rock formations of the Washoe district: to Professor Whitney, who determined by barometrical measurements the elevation of the mountains and valleys, and determined the geologic age of the deposits near Dayton; and, finally, to the able report of Mr. Clarence King, recently issued from the Government press, we acknowl-

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edge our obligations. With the extended labor of these gentlemen before us on the general geology of the country, it is not a subject of regret that economic geology, with its special application, forms the limit of our investigation.

The entire region in the vicinity of Virginia City gives evidence of extensive dynamical disturbance, continued through a long period of time with more or less activity. Volcanic action to an extent and of an intensity not met with in modern times, has played an important part in the formation of numerous mountain-peaks, and in giving to the scenery a broken and rugged aspect, which is heightened by the sterility of the soil. Without a tree or shrub to relieve the eye, excepting the sickly-looking artemesia or sage-brush, struggling for existence, the broken and jagged trachytic rocks impart a character of wildness to the country, and the name of "Devil's Gate," given to one of the passes, indicates the feeling which prompted the first rude settlers to bestow such a name to the rugged scenery. Passing from Virginia City eastward for a distance of four miles in a right line, we reach the comparatively fertile valley of the Carson, while within the range of vision to the northward the sand clouds may be seen sweeping over the desert region known as the Sink of the Humboldt. We do not design giving a full topographical description of this interesting but sterile country, but desire to convey the idea of the worthlessness of these mountains except for the boundless wealth in minerals which they contain.

The various ages and modes of deposit of the rock formations have an important practical bearing, and require our special attention.

Mount Davidson, from its height and position, as well as from its lithological character, was the first to make its appearance amid the snow mountain peaks of the Washoe district. It is a syenitic rock, compact in structure, difficult to work, and bears important relations to the Comstock lode, forming its west wall for a considerable distance, if not through its entire extent. The elevation of Mount Davidson has been determined at 7,827 feet, its summit rising 1,622 feet above Virginia City, and has a range of outcroppings of quartz rock skirting its eastern side some 1,500 feet below its summit.

To the eastward on the line of the proposed tunnel are numerous hills, intersected by valleys or deep ravines, extending to the plains of the Carson River.

Next in order to the syenite is an extensively diffused volcanic rock called propylite, which was spread over the entire portion of the tunnel section. This is the green-stone or "green-stone trap" of the miners, and works with great facility. It is thickly studded with fine granules and occasionally with distinct crystals of sulphuret of iron. It is important as furnishing the eastern or hanging rock of the Comstock lode.

Through the propylite, at a later period, volcanic craters have been opened, and formed by their ejections hills or mountains of considerable elevation, varying much in their color, compactness, and the circumstances attending their formation. The most common variety of this trachytic rock is a simple greyish, pasty mixture, with its particles loosely cemented together, easily worked with the pick, except at considerable depths, when it becomes compact and is useful as a building-stone. The structure of the rock indicates that the volcanic ashes of which it is composed were ejected in connection with water or steam and cooled rapidly after its deposit. The mud volcanoes of Western Mexico furnish a type of this form of deposit. Another variety of the same color, with numerous crystals of glassy feldspar diffused through its mass, from which it has received the name of sanadin trachyte, was deposited

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in a similar manner, but cooling slowly gave an opportunity for the play of chemical affinities, by which the crystals were formed, and a more compact structure of the rock resulted.

A third variety, with a color ashy grey, or of a more or less deep red color, is found one and a half miles from the mouth of the tunnel. With the same chemical constituents, except the addition of oxyde of iron, we have in this a firm, hard rock, working with difficulty.

Still another variety of considerable practical importance is met with which has been passed through for a distance of 750 feet at the commencement of the tunnel, which may be distinguished under the name of trachytic conglomerate. It is characterized by numerous angular masses, sometimes of great size, cemented together by the ash-colored trachytic matter, and offering to the drill and giant powder serious obstacles to rapid progress in the work of constructing the tunnel. This formation is due to the breaking down of the walls of the crater and the projection of their broken up, angular masses into the ashy deposits from the volcano. These walls were, at this place, composed of metamorphic porphyry, the fragments of which are now held together firmly by the cementing material.

Numerous recent instances might be cited for illustrating the action of ancient volcanoes, the same laws which governed in former times being operative at the present, but with far less intensity.

In 1813 a volcanic eruption of ashes occurred on the Island of St. Vincent, which fertilized the Island of Barbadoes, the ashes falling in Bridgetown to a depth of several inches. The amount of matter thrown out must have been immense, as the transfer was made in opposition to the trade-winds.

The once beautiful and symmetrical volcano of Consaguina, in Central America, some forty years ago exploded with a report heard at Santa Fé de Bogota, a distance in a right line of one thousand eight hundred miles, and emitted ashes in such quantities that, for hundreds of square miles, the sun was obscured, and for ten days made a midnight darkness over most of Honduras and San Salvador. The ruins of Pompeii and Herculaneum furnish us with well-known examples of similar volcanic eruptions.

The other formations on the line of the tunnel are of much less consequence in this connection. At the St. John's mine, on the Monte Christo lode, is a deposit of granular limestone, which disappears at some 200 feet in depth where the propylite is in place.

Andesite, a hard hornblendic rock, caps one of the hills near the mouth of the tunnel. This is of volcanic origin, and is only less hard than the sidian, of which a few scattered specimens were met with.

To recapitulate, we have for a basis the syenite of Mount Davidson, then propylite, (with porphyry,) sanidin trachyte, loosely aggregated and compact trachyte, trachyte conglomerate, andesite, and carbonate of lime on or near the line of the tunnel.

It becomes a matter of much importance to determine the character of the rock excavation in estimating the cost of construction and the time required to complete the tunnel. The quartzite met with in the Hoosac tunnel has greatly impeded the progress of that great work, causing a weary delay, and leading to great expense in construction. With this example before us for not relying upon surface indications alone for the character of the rock excavation, your commissioners sought every indication possible for obtaining a correct idea of the formations through which the Sutro Tunnel will be required to penetrate. We were still more strongly impressed with the necessity for using a

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precaution in our determinations, as unexpected results had already been obtained in the portion of the tunnel or heading which had been driven some 2,300 feet. The surface indicated that, for this and a much greater distance, the tunnel would pass through trachytic rock only. On the contrary the following results were obtained, viz:

	Feet.
1. Trachytic conglomerate	750
2. Trachyte	500
3. Trap-dyke	40
4. Red clay	70
5. Blue clay *(porphyritic)*	100
6. Porphyry	840

The firmness of the conglomerate will be sufficient to support itself without timbering. All the others will require this support, and the blue clay continually acts upon and crushes the frame-work, requiring constant care and frequent excavations behind the timbers to prevent the complete closure of the adit. This difficulty is encountered in many of the mines, until the clay becomes sufficiently dry to resist the great pressure of the vast body of the same material behind it. No part of the tunnel will cost as much per hundred feet as that passing through this clay.

In an economic view, the porphyry and propylite may be considered the same, having about equal density, and working equally well under the drill. In the former, a greater liability exists of encountering clay seams, as a result of the disintegration of the feldspar, which enters largely into its composition.

With but comparatively slight exceptions, these two formations will be the only ones encountered in the construction of the tunnel, for they underlie the trachytic and other volcanic rocks, and, except in chimneys, these later formations will not be encountered.

The propylite by exposure to moist air too readily disintegrates in consequence of the changes effected in the sulphuret of iron, with which it is filled, and will require to be timbered in consequence. All the circumstances named have been taken into consideration in forming an estimate of cost, and as an element in determining the time required in construction.

By the cooling of the vast field of propylite which had been poured out, we may assume that the contraction was sufficient to cause a vast fissure near or at its junction with the sienite.

The period of active volcanic movement again occurring, there was injected from below a body of quartz in quantity sufficient to fill this fissure. Practically, it does not matter whether this was accomplished by solfataric action or by direct volcanic forces, or whether we consider the metallic wealth deposited in the lode by super-heated steam and the action of acids, or consider that with the silex the gold and silver were thrown up by the same force.

We know that for a distance of five miles, with a varying width of from 50 to 500 feet, and to an unexplored depth, the Comstock lode is found one of the richest, most productive and extensive in the records of mining.

It is, however, of very great importance to determine whether the Comstock be a true fissure-vein, as declared by most intelligent geologists, or be but a gash-vein, with its material filled in from adjacent rocks. The permanency of the mining interests of Nevada depends upon which of these views prove correct. In the first contingency we may claim that no true fissure vein has ever been worked out, and from

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analogy we may draw the conclusion, with a good degree of certainty, that the Comstock cannot be exhausted by the labor of man. If but a gash-vein, the conditions are so changed that exhaustion must at no distant day be the result. In a careful examination of the rocks near the lode, we do not find a loss of any proportion of the quartz which belongs to them. From whence, then, could this mineral have been derived? Again, the only source of supply by washing in must have been obtained from a higher level, or the syenite of Mount Davidson. This would imply a decomposition of that rock; and the hornblende, one of its constituents, would as readily be carried into the opening as the quartz. The hornblende is not found mingling with the siliceous deposit, therefore the latter could not have been received from the syenite.

We are left to the only possible explanation of the occurrence of this wonderful deposit, *i. e.*, that it is a true fissure-vein filled from below, and, like other fissure-veins, extends to a depth beyond the power of man to reach. The explanation of the clay selvages bounding the vein-matter, the formation of "horses" by the falling of portions of the hanging rock, the exhaustion of rich bonanzas or bodies of paying ore, the barren condition of much of the quartz, are none of them peculiar to the Comstock lode, but are met with in other mines of a similar character, and have been fully described elsewhere. The crushed and crumbly condition of much of the vein-matter has been ascribed to dynamical action, supplemented, doubtless, by chemical changes in the sulphurets met with in considerable quantities in the lode. With reference to the future productiveness of the mines, until carefully explored at deep levels, much must be left to conjecture. The mere fact that the Comstock is a true fissure-vein establishes that the vein-matter or quartz extends downward indefinitely, but does not prove that this material is charged with the precious metals. Reasoning from the past history of fissure-veins in other countries, we have just grounds for believing that the metallic wealth, thousands of feet below the surface, will fully equal or be even greater than that from higher levels. The Sampson mine in Germany has reached a depth of 3,000 feet without any diminution of its yield of silver. This, compared with the Comstock, is a small vein, but for that very reason is far more likely to be lost by a fault than one of the magnitude of the lode under consideration.

It is quite probable that at great depths the metals are more equally distributed through the vein matter, in which case the very rich ores will not be met with, but the whole mass will yield an equally favorable result, without the large expenditures required in drifting for bonanzas. The recent discoveries in the Crown Point and Belcher mines of immense bodies of "rich rock" at nearly 1,700 feet below the initial point is a most encouraging feature for the permanent value of the lode.

We had the privilege of examining such portion of the bonanza of the Crown Point as had been uncovered, estimated to be worth $15,000,000, with a prospect of equal value at a still greater depth. Judging from the present quotations of the Belcher stock, this latter mine should give even greater results than the Crown Point.

One other feature of the recent discovery becomes important to the mine owners and to the country.

Upon the upper levels of this and some other mines, if not in all, the yield of gold was greater in value than of silver. As the mining progressed in depth, the silver yield to the ton of ore became the greater

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but in the new discoveries the more precious metal is restored to its previous relative proportion.

An examination of the reports of superintendents gives us a much higher per cent. of the gold contained in the ore secured than of silver. In the report of the Savage mine, of this year, we find that the *loss* in working from the assay value of the ores is, of gold $25\frac{1}{10}$ per cent., of silver $34\frac{2}{10}$ per cent.

The larger proportion of gold in the ore, the less absolute loss is made in the working.

The above statement is the result of the workings in the Occidental mill, under the direct control of the Savage Company, and includes all savings from slime and tailings secured to the company.

In the Custom's mills, the report shows a less favorable result on the silver product, as follows: Gold loss, $23\frac{1}{10}$ per cent.; silver loss, 44 per cent.

It may not be out of place to remark that the loss on the gold product is ascribed to "float gold," which might possibly be secured by running the surface-water or "float" through sponges. The loss of silver is due to a failure in the works to secure the sulphuret of silver, and, to a limited extent, to particles of clay, carrying with them minute portions of silver, as suggested in the report of Mr. Clarence King.

It is well understood by all who have given their attention to the subject, that the metallic deposits are not equally diffused through the vein matter, but are found in detached bodies called "bonanzas." This rule holds good in the Comstock lode as well as in all other silver lodes, having quartz as a gangue. An examination of the mining map, exhibiting the workings of this lode in detail, proves the deposition of the rich ores of the precious metals in *bodies*, and the comparatively barren quartz in other portions.

There is no law yet evolved from experience or science for determining the position of these rich bodies of ore; exploration alone can discover their position and value. It is, however, sufficient to know that they are confined to the vein-matter, and their discovery may be expected so long as we confine our workings within the boundaries of the "country rocks."

By the present system of working the ores from these mines, rock that yields by assay less than $30 to the ton, cannot be reduced at a profit.

The amount of low-grade ores, ranging from $10 to $25 in the Comstock lode, amounts, by the testimony of some witnesses, to millions of tons. The following forms a small portion of the evidence obtained upon this subject: Colonel Requa, superintendent of the Chollar Potosi mine, in his various reports, mentions the large amount of ores that at some future time may be made available to the owners, that with present prices for labor and by the present processes of reduction cannot be utilized. He stated, personally, that very large bodies of sixteen-dollar ore exist in the mine.

A former superintendent of the Empire and Imperial mine stated that while in charge, he struck a body of ore that yielded $19 per ton, which, at the then cost of mining, transport, and reduction, did not pay. This body was prospected in the middle of the lode, more than 100 feet wide, to a depth of 6 feet only. How large this body of ore may be he was unable to state.

Mr. George Atwood, at present superintendent of the Eberhart mine, has worked as foreman, &c., for eight years on various mines of the Comstock lode, states that in the south mine of the Ophir a body of ore exists that has been mined and used for filling in stopes for a distance

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of 300 by 300 by 100 feet, which will average, by assay, $20 per ton. A large body in the north mine, yielding but little less, is found in place. He further states that in the Crown Point, on the 200-feet level, an estimated amount of 100,000 tons of ore, that will assay $20 per ton, may be found. Was for three years connected with that mine, and is thoroughly acquainted with the upper levels.

From our own observation, and the evidence of others, we do not hesitate in stating that vast amounts of what are designated as low-grade ores abound in these mines, that may yet be made available in increasing the national wealth.

At each extremity north and south from the principal mines the workings are carried on exclusively for gold. The Sierra Nevada Company, the most northerly of the group now in operation, is understood to be profitably engaged in working the loose surface rock and soil. At the other extreme the Succor mine and mill, situated on Gold Cañon, are in operation; the vein of precious metal having been followed into the mountain 1,300 feet, and the ore is taken to the mill direct through a tunnel. The facilities for working and the economy exhibited have saved the stockholders from the usual heavy assessments.

A careful survey of the adit of this mine developed an unexpected fact. Following the windings of the tunnel, which kept pace with the sinuosities of the vein of ore, we reached the same character of quartz rock that had become familiar to us in the mines of the Comstock. It was an accidental discovery of the miners during a search for the gold vein, which had been lost from a fault. This "white lode" assays $22 60 per ton. By taking the bearings by compass in this and in the Crown Point mine, they indicated a connection with each other. The theory has been that near the Overman mine the vein or lode bent around to American Flat, where it ceased. Further research may be necessary to establish with certainty the view, that a branch at least of the Comstock lode passes down Gold Cañon and shows itself in the Succor mine, one and a half miles below the Crown Point.

The appearances indicate that the "white lode" and the gold vein will at no great distance unite to form a rich lead, and when thus joined the value of the gold and silver lead will be condensed into the gangue of one with the relative proportions of gold to silver now met with in the Crown Point.

The value of the proposed Sutro Tunnel simply as an exploring work is so evident as to be scarcely called in question. Cutting, as it does, at right angles two or more lodes before reaching the Comstock, that, in Europe, would be deemed valuable; the determination of their wealth or poverty would prevent further ruinous outlays in prospecting. There is no certainty that rich bonanzas will be met with in the progress of the work, but that an abundance of moderately rich ores will be found is quite probable. We found at the Occidental mine, on the Monte Christo lode, two adits or tunnels had been run, one to the distance of 1,850 feet for a considerable distance through crystalline limestone, after which porphyry and then propylite made their appearance as we penetrated the tunnel.

The quartz vein is often broken down and crumbly and colored by oxide of iron. In the limestone excavated we noticed arborescent crystals of manganese. Extensive galleries and wide chambers were met with, from which rock working from $10 to $33 had been taken. The upper tunnel had been run for 1,500 feet and connected by a shaft to the lower one. We noticed that the current of air passed down the shaft and out at the lower tunnel. Much of the quartz rock is near

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or quite barren, but we were informed that millions of tons assaying from $8 to $10 to the ton existed in the mine. We believe this to be a fair index of the character of the Monte Christo lode which we visited in other localities. What developments will be made at the great depth at which the tunnel will cross its track is, of course, uncertain. The heading which has been run will, if continued a few hundred feet farther, cut the "Great Flowery lode," with what result we are not prepared to predict.

We made an examination of the Lady Bryan mine, said to be located on this lode. The croppings of quartz rock is enormous in quantity, forming a hill about 100 feet high, and would yield for the whole mass, as we were informed by the superintendent, an average of $8 per ton of silver.

An open cut has been made through the hill or body of quartz rock into a large basin formed by the excavation of material, some of it valuable, but a large quantity too poor for working.

Short drifts have been run into the hill-sides in various directions, which at the time of our visit were not worked. The richer ores were being assorted for milling, the mine furnishing but eight or ten tons per day of valuable material. Only ten men were employed on the works at the time, the mine having recently passed into new hands.

With reference to the tunnel cutting *blind lodes*, we are not prepared to express an opinion, the very name implying a complete want of knowledge of the subject. The possibility barely exists, with the past history of mining giving strong practical evidence against the probability of a favorable result.

As an exploring work, we think the Sutro Tunnel may claim to determine with sufficient certainty the ore-bearing character of the Great Flowery and Monte Christo lodes, and settle definitely the question whether the Comstock lode at great depths continues in richness; or, as is believed by some, becomes worthless as the deep levels are opened. It is somewhat remarkable, as bearing on this subject, that the Crown Point, once justly esteemed valuable, and ranking high in the stock board, became almost worthless under the supposition that the mine was worked out. By the energy and perseverance of the superintendent, the owners were rewarded by the discovery, at deep levels, of one of the richest bonanzas yet found on the Comstock lode, which sent the stock up from $2 50 per share to over $300. It must be borne in mind that at two or three points shafts reaching as low as the tunnel will be sunk by the time of its possible completion. This will not be so complete an exposure of the value of the lode as drifts from the lateral tunnel, made at comparatively small expense, at numerous points along its course.

We cannot but think, therefore, that, as an exploring work for deep mining, the Sutro Tunnel may justly claim favorable consideration.

Respectfully submitted.

H. G. WRIGHT,
Lieutenant Colonel of Engineers, Brevet Major General.
J. G. FOSTER,
Lieutenant Colonel Engineers, and Brevet Major General, United States Army.
WESLEY NEWCOMB,
Civil and Mining Engineer.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

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OFFICE SUTRO TUNNEL COMMISSION.
New York, December 2, 1871.

GENERAL: I have the honor to transmit herewith a letter from Mr. Adolph Sutro,* in which he states that he has not been able as yet to prepare the paper which he desired to furnish, relative to the advantages of the tunnel as compared with the present method of working the mines; but he incloses a printed copy of a speech delivered by him at Virginia City, in support of his project, and desires that it may be added to the appendix of the commissioners' report.

This printed speech is also inclosed, and I would ask that it be attached to the appendix of the report, as desired by Mr. Sutro. I would further suggest that his letter be also appended.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Lieutenant Colonel of Engineers, Brevet Major General,
Senior Officer of Commission.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

APPENDIXES.

APPENDIX A.

Estimates of cost of the Sutro Tunnel.

Cost of sinking shaft No. 1, 109 square feet area and depth of 530 feet, including tools, labor, and materials of all kinds, at $40 24 per foot of depth, (being the average cost in the seven principal mines of the Comstock lode)		$21,327 [illegible]
Same, shaft No. 2, 109 square feet, 1,025 feet deep, at $40 24		41,24[illegible]
Same, shaft No. 3, 109 square feet, 1,319 feet deep, at $40 24		53,07[illegible]
Same, shaft No. 4, 109 square feet, 1,499 feet deep, at $40 24		60,319 [illegible]
Same, shaft No. 5, 109 square feet, 1,465 feet deep, at $40 24		58,951 [illegible]
Same, shaft No. 6, 109 square feet, 1,465 feet deep, at $40 24		58,951 [illegible]

Preliminary tunnels or drifts.

Cost of labor, tools, and materials of all kinds, for drift of main tunnel, 6 feet wide, 7 feet high, and 19,790 feet long, at $19 90 per running foot, (being the average cost of 2,185 feet completed July 1, 1871)	$393,821 00	
Deduct value of one-half of timber of drift, which may be used again as the enlargement progresses	14,644 60	
		379,176 [illegible]
Cost of labor, tools, and materials of all kinds, used in drifts of branch tunnel, 6 feet by 7 feet, by 12,000 feet long, at $19 90 per running foot	238,800 00	
Deduct value of one-half timber of drifts used a second time	8,880 00	
		229,920 [illegible]
Cost of enlargement of drift to full size of tunnel, 13½ feet by 12 feet, by 19,720 feet long, 2,366,400 cubic feet, at 25 cents		591,600 [illegible]
Same, of branch tunnel, 12,000 feet long, 1,440,000 cubic feet, at 25 cents.		360,000 [illegible]
Cost of timbering main tunnel full size, 19,720 feet in length, at $17 34 per running foot		341,944 [illegible]
Same, of the branch tunnel, 12,000 feet, at $17 34		208,080 [illegible]

* See Appendix M.

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Cost of general material and sundries, including surveying instruments, large transit building for the same, boarding and lodging houses, barns, horses, carts, magazines, blowers, air-pipes, &c., for four shafts of main tunnel	$66,439 00
Same, for branch tunnel, two shafts	20,000 00
Cost of hoisting and pumping engines and machinery for four shafts of main tunnel	121,679 00
Same, for branch tunnel, two shafts	108,930 00
Cost of boilers and parts, four shafts, main tunnel	33,736 40
Cost of boilers and parts, two shafts, branch tunnel	25,256 00
Cost of labor and materials for the erection of machinery, and temporary buildings to cover the same, for the four shafts of main tunnel	32,265 00
Same, for the two shafts of branch tunnel	21,510 00
Cost of material and time employed in attending machinery during the sinking of four shafts, main tunnel	138,734 27
Same, for the two shafts of branch tunnel	82,489 50
Same, during the running of the preliminary tunnel of the main tunnel	324,784 90
Same, of branch tunnel	216,523 26
Cost of appliances for hauling rock and ore out of main tunnel	50,000 00
Cost of appliances for hauling rock and ore out of branch tunnel	35,000 00
Add for office expenses, superintendence, engineering, and contingencies, 20 per cent	736,388 25
Total cost in gold	4,418,329 50

RECAPITULATION.

	Main tunnel.	Branch tunnel.
Sinking shafts	$175,969 52	$117,903 20
Running preliminary tunnels	379,176 40	229,920 00
Enlargement of drifts to size of tunnel	591,600 00	360,000 00
Timbering full-size tunnel	341,944 80	208,080 00
General materials and sundries	66,439 00	20,000 00
Engines and machinery	121,679 00	108,930 00
Boilers and attachments	33,736 40	25,256 00
Erection of machinery and temporary buildings for same	32,265 00	21,510 00
Attending machinery in sinking shafts	138,734 27	82,489 50
Ditto in running preliminary tunnels	324,784 90	216,523 26
Endless wire-rope, &c	50,000 00	35,000 00
	2,256,329 29	1,425,611 96
Office expenses, superintendence, engineering, contingencies, 20 per cent	451,265 86	285,122 39
	2,707,595 15	1,710,734 35

Time required to complete tunnel.

Depth of shaft No. 4, (the deepest)	1,499 feet.
Average daily progress in the shafts of the Comstock	3 feet.
Number of days required to sink shaft No. 4 1,499 feet	500 days.
Whole length of main tunnel	19,790 feet.
Distance penetrated by preliminary tunnel, July 1, 1871	2,185 feet.
Average daily progress in preliminary tunnel	$4\frac{15}{100}$ feet.
Distance penetrated when shaft No. 4 reaches tunnel level	4,260 feet.
Distance remaining to be penetrated at that time	15,530 feet.
Number of available working headings	9
Greatest distance to be penetrated by any drift to meet the drift from the adjacent shaft	2,432 feet.
Time required to run above distance at 4.15 per day	586 days.
Total time required to sink shafts and run drifts	1,086 days.
Additional time required to enlarge tunnel to full size	100 days.
Total time required to complete main tunnel	1,186 days.
Number of years required to complete main tunnel	$3\frac{1}{4}$ years.
Number of feet of branch tunnel run from four headings at bottom of shafts Nos. 5 and 6, 1,465 feet deep, when main tunnel is completed	414 feet.
Additional time required to extend branch tunnel to 12,000 feet working two headings	50 days.
Total time to complete main and branch tunnels, (manual labor)	$3\frac{4}{10}$ years.
Total time to complete main and branch tunnels, (by machinery)	$2\frac{3}{10}$ years.

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APPENDIX B.

Circular to superintendent of mines.

OFFICE SUTRO TUNNEL COMMISSION,
Virginia City, Nevada, July —, 1871.

SIR: By the act of Congress approved April 4, 1871, this commission is required to report, among others, upon the following points, viz:

1. The value of the bullion extracted from the mines on the Comstock lode.
2. Their present and probable future production.
3. The geological and practical value of said tunnel as an exploring work.

Much of the information required by the above can be obtained only from the companies engaged in mining on the Comstock lode; and as regards the rest, the information which the companies can afford will be of the highest value to the commission in the discharge of its duties. I am, therefore, instructed to request of you your views in writing, upon the points above quoted, as well as upon any others which you may deem to have a bearing upon the question of the construction of the Sutro Tunnel.

I also take the liberty, under the instructions of the commission, to append a series of questions having a bearing upon the portions of our duties not enumerated above. your answers to which will be important in making up our estimates of the probable cost of the proposed tunnel, and its value as an aid to deep mining on the Comstock lode.

Should your reply to the foregoing not be ready before the commission leave Virginia City, please forward it addressed to me at the Army Building, New York City. The earliest practicable answer will, however, oblige.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Brevet Major General, Senior Officer of Commission.

To ——— ———,
Superintendent of ——— Mine.

The following are the questions to which answers are asked:

1. Cost at various depths of sinking shafts, estimated by cubic foot removed, or by the running foot for a shaft of given dimensions.
2. The present cost of timbering the same, with increase, if any, with the depth.
3. The cost of drifting in the various rocks met with in your operations; estimated either by the cubic foot or by the running foot, specifying the dimensions of the cross-section.
4. The cost of timbering the same.
5. The daily progress made in the shafts and drifts through the various rocks, the largest force that can be worked to advantage being employed.
6. The cost of raising ore, water, &c., from various depths.
7. The cost of pumping at your mine for twelve months; preferably for the year ending June 30, 1871.
8. Has the water in your mine increased or diminished with the depth, and in what proportion?
9. The cost per ton of ore for milling; and where the cost of transportation to the mill is included, the cost of the latter.
10. What is the present cost of the artificial ventilation of your mine, and how does it increase with the depth?
11. How long a time at the present progress of working will it require to exhaust all the profitable ore in the mine, above the 600-foot level?
12. How long between the 600 and 1,000-foot levels?
13. At what depth will the present machinery be available for hoisting the ore or clearing the mine from water?
14. What additional expense will be incurred, if any, per 1,000 feet of additional depth for the purposes above named, calculating from the 1,000-foot level?
15. What is the width of the lode and also of productive vein-matter at the various levels of your mine?
16. What has been the expense of prospecting the mine for the year passed?
17. How does the pay-ore compare at each level, from the surface downward?

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APPENDIX C.

OPHIR.

OFFICE OPHIR SILVER MINING COMPANY,
Virginia City, Nevada, September 21, 1871.

SIR: In compliance with your communication of July 28, asking my views upon the question of the construction of the Sutro Tunnel, I beg leave to respectfully submit the following:

Answer to congressional question No. 1, the value of the bullion extracted from the mines on the Comstock lode.—Bullion extracted from the Ophir mine since the incorporation of the company, in July, 1860, $4,631,539 10.

Nos. 2 and 3. Their present and probable future production, and the geological and practical value of said tunnel as an exploring work.

In answer to congressional question No. 3, I will briefly state, as to its geological value, I am not competent to judge; but as to the practical value I will offer a few remarks: First, I will consider its value as an avenue through which all the mines on the Comstock may be worked, as it is claimed by Mr. Sutro that all the machinery on the lode may be dispensed with both for hoisting and pumping, and the entire business of or work of all the mines be carried on through his tunnel. You will please consider the tunnel with all its lateral drifts completed, and all the mines on the Comstock being worked through it. No machinery is used on the surface.

We have, to begin with, (page 19, "Sutro Tunnel,") 3,000 miners to carry to and from their work, an average distance from the month of the tunnel of four and a half miles. These 3,000 miners divided into three shifts of eight hours each, gives us 1,000 men on each watch. Allowing ten men to a car, it would require one hundred cars to convey the men into the tunnel. The train would occupy 1,200 or 1,500 feet in length of the tunnel, and when the head of this train would reach the place of destination the rear cars would be quite an inconvenient distance back from the place of destination, thereby creating much confusion and more or less delay. It is at this point that the miners' greatest trouble begins, their respective stopes and places of work being far above them. They commence to climb the ladders, and go up various heights, many from 500 to 1,000 feet. They arrive at the place where their day's work is to be done in an exhausted condition, positively unfit and unable to do a day's work.

The timbers used in the various mines are to be conveyed to their respective destinations by the same tedious, slow, and expensive routes—expensive, because time in this country is money in fact, the most expensive commodity that is employed in the working of these mines.

Suppose a cave is threatened in some one of the most distant or inaccessible of the mines. A car-load or two of timbers immediately and judiciously used, might, and often does, prevent a disastrous cave. By the present mode of working, in such a contingency as the above, the miner would send his order up, and in a very few minutes the return cage would bring the desired timbers, and in a few minutes more the timbers would be in place, and the threatened disaster averted. How would it be in working through the tunnel? The miner would first give his order for timbers, the order conveyed down the ladder, probably 1,000 feet to reach the tunnel, then out of the tunnel, a distance of four or five miles, to the carpenters' shops at the mouth of the tunnel; the timbers procured and sent by return cars to the foot of the upraise, then raised, by some as yet unexplained process, to the point of danger or trouble. In this way, hours might elapse before the much-needed timbers would arrive, and then they would probably arrive too late to prevent great damage.

Another disadvantage in working the mines through the Sutro Tunnel is, the mouth of the tunnel being located several miles farther from the timber and lumber supplies, would necessarily increase the cost of the same two or three dollars per thousand more than when delivered at Virginia or Gold Hill.

The foregoing are some of the practical objections to using said tunnel as an avenue through which to work the mines on the Comstock, and as a practical miner of more than forty years experience in various kinds of mining, I make this assertion, that should the tunnel, with all its lateral drifts, be offered *free of charge*, not one mine on the Comstock would be worked through it. And why? Because the present mode of working is cheaper and more expeditious.

Now I will offer a few remarks regarding the various charges imposed upon the mining companies for the privilege of working through this tunnel. Mr. Sutro (page 166 of his book) estimates the daily yield of all the mines on the Comstock at 1,500 tons. For the right to transport this ore through the tunnel, the mining companies must pay 25 cents per ton per mile, or about an average of $1 12½ per ton, amounting to $1,687 50 per day, or $615,937 50 per annum. There should be added to this a like amount for débris or waste, which, including that from all the shafts, winzes, upraises, and drifts purely of a prospecting character, would be more likely to overrun than fall

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below this amount, which gives us $2 25 per ton, or $3,375 per day, or the large sum per annum of $1,231,875.

In addition to this, we have the transportation of the miners, which, as he estimates 3,000 men to raise 1,500 tons of ore, gives us two men for each and every ton of equal to $1 per ton, or a total thus far of $3 25 per ton, or $4,875 per day, or the sum per annum of $1,779,375.

As large as this sum is, we must again add to it the cost of conveying the timber to the respective mines, which is 25 cents per ton per mile, (40 cubic feet or 4 board-measure being reckoned as one ton,) and he estimates the total consumption of timber per annum (page 18) to be 16,000,000 feet, which gives us 33,333⅓ tons; this at an average transportation distance of four and a half miles, amounts to $1 per ton, or a total for this item of $37,500; or 6.8 cents per ton of ore, added to the above amounts to $1,816,875. And yet we are not quite through, for we still have to add an indefinite amount of 50 cents per head for all superintendents, foremen, their assistants, attachés, and visitors that go in and out of this famous tunnel. Taking Mr. Sutro's estimate, we now have taxes in specified items amounting to $3 31.8 per ton, and for what? For the privilege of working the mines in a more expensive and inconvenient way than the present mode of working them. But thus far there is no redeeming feature in the contract. It is this: it is optional with the different mining companies whether they pay any or all of the before-mentioned tariffs, for if they do not work through the tunnel they need not pay any of them.

We now come to a tax that is more arbitrary in its character. No mine on the Comstock lode can escape its provisions. It is what is termed the two dollars per ton royalty, which is intended to be a compensation for draining the mines, and is claimed to be a cheaper mode of drainage than that of pumping, the mode now in use. I will now proceed to the consideration of that branch of the Sutro Tunnel question practically considered. These mines have been worked for about twelve years, more or less extensively. It is little more than ten years since I first took charge of a mine on the Comstock. For about three-quarters of that time I have been in charge of mines here, having been absent from this locality about two and a half years of the last ten. Hence I speak on this question from experience.

The mine that I am now in charge of, and have been for more than three years past (the Ophir,) has been, and is still, celebrated as being much the wettest mine on the Comstock, and yet we have no difficulty in overcoming all troubles of an aqueous nature, neither do we anticipate anything in the future of that character that will cause us serious trouble.

After these general remarks I will proceed with a few estimates. Mr. Sutro (on page 17) gives us an estimate of what it will cost to pump in all the mines on the Comstock when a depth of 1,550 feet is attained. After very elaborate figuring, he gives us the astonishing sum of $5,911,560 per annum. That depth is very nearly reached at the time in all the prominent mines, and a comparison can now very justly be made between the estimates made by Mr. Sutro and the actual cost, which, taking the year as a guide, for the year ending May 31, 1871, will not exceed the sum of $1500 000 for all the mines, showing the estimate of Mr. Sutro to be very wild, and renders calculations based upon that estimate unreliable in the extreme. What is the cheapest and most economical mode of freeing the mines on the Comstock from water—the present plan of pumping, or by means of the proposed Sutro Tunnel under the existing franchise?

I state that the present cost of pumping will not exceed $150,000 per annum.

Taking the estimate of Mr. Sutro as correct, that the daily yield of the mine is 1,500 tons, or 547,500 tons per annum, the two dollars per ton royalty give a sum per annum of $1,095,000, the cost of drainage through the tunnel.

Comment on these two propositions I hold to be superfluous. There are two principal causes or reasons operating to reduce the cost of pumping on the Comstock in the future as compared with the past; and these are, first, the great reduction in the cost of fuel, (and that reduction is bound to continue until it reaches a price about half the present cost;) and, secondly, the positive decrease in the quantity of water as greater depth is attained; for I hold that there is no more certain event of the future than that the water will decrease in the Comstock as the mines grow deeper, the opinions of Mr. Sutro, Professor Richthofen, or any other scientific gentlemen, to the contrary notwithstanding, and the idea of running a tunnel four miles or more in length, at an outlay of millions of dollars, to tap what is almost certain to be very nearly a dry fissure, seems to me to partake of the absurd in the extreme. This is a dry country, and all who have looked upon it know it.

As a ventilator, this tunnel, if finished, would amount to just what a connection between any two or more mines would—no more and no less. Neither one could possibly be made to ventilate any exploring or prospecting work for which some mode of artificial ventilation, either by patent blower, air-pumps, or some other more efficient method, is necessary.

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But the most important question of all in this connection presents itself, and, as yet, is unanswered—does ore in paying quantities exist in the Comstock at these great depths?

Taking a practical and the most hopeful view of this question that the facts thus far developed will warrant, I am compelled to say there are grave doubts, notwithstanding Professor Richthofen comes to the rescue and assures us that by his scientific and theoretical vision he sees it, and there is no doubt but ore in paying quantities exists in the Comstock fissure from the surface to untold depths. But gentlemen of his class have deceived us so often that, I am sorry to say, we miners have little faith in their scientific prognostications.

I will now proceed to consider the following questions propounded by the commission, so far as they apply to the workings of the Ophir mine:

1. Cost at various depths of sinking shafts, estimated by the cubic foot removed, or by the running foot for a shaft of given dimensions.

Actual cost of sinking main shaft from 720 feet to 1,002 feet=282 feet.

Time, 3 months—June, July, and August, 1871. Dimensions of shaft, outside of timbers, 18 feet 8 inches by 7 feet 4 inches.

		Total cost.	Cost per foot.
Labor:			
Miners	$10,092 00		
Carmen	959 00		
Blacksmiths and helpers	1,242 00		
Engineers and firemen	1,300 00		
Wood-hauling	185 00		
		$13,778 00	$48 85$\frac{8}{10}$
Powder:			
647½ pounds giant powder	$760 81		
500 pounds Hercules powder	310 00		
Fuse and caps	51 00		
		1,121 81	3 97$\frac{8}{10}$
Steel:			
757 pounds, at 20 cents		151 40	53$\frac{68}{100}$
Candles:			
1,300 pounds		244 65	86$\frac{75}{100}$
Wood:			
276½ cords, at $10		2,765 00	9 80$\frac{5}{10}$
Total amounts		18,060 86	64 04$\frac{8}{10}$
Cost per cubic foot		46$\frac{79}{100}$	

2. The present cost of timbering the same, with the increase, if any, with the depth.

Actual cost of timbering main shaft.

47 sets timbers, 6 feet each = 282 feet.

	Total cost.	Cost per foot.
Timbers in set:		
1,912 feet by 47 sets = 89,864 feet, at $22 per M	$1,977 00	$7 01
Labor:		
1 carpenter and 1 timberman, at $5 each per day	920 00	3 26
Total amounts	2,897 00	10 27

No increase for greater depths.

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Total cost of sinking and timbering main shaft 282 feet.

	Total cost.	Cost per foot.
Cost of sinking	$18,060 86	$64 04⅓
Cost of timbering	2,897 00	10 27
Total amounts	20,957 86	74 31⅓

3. The cost of drifting in the various rocks met with in your operations, estimated either by the cubic foot, or by the running foot, specifying the dimensions of the cross-section.

Cost of running drift from 700-foot level, 866 feet.

Blasting ground. No timbers required. Size of drift, 4 feet 6 inches wide by 6 feet 6 inches high. Time, 8 months; February 15 to October 15, 1869. Six-hour watches—three men on each watch.

		Cost.	Per foot.
Labor:			
Miners	$16,596 00		
Blacksmiths	1,452 00		
		$18,048 00	$20 84
Blasting material		3,099 72	3 57⅔
Steel and tools		132 72	15⅓
Candles		467 00	53⅔
Total amounts		21,747 44	25 11
Cost per cubic foot		86$\frac{58}{100}$	

4. The cost of timbering the same.—No timbers used.

5. The daily progress made in the shafts and drifts through the various rocks, the largest force that can be worked to advantage being employed.

In main shaft, described in answer to question No. 1, six-hour watches are worked, with six men on each watch. Average daily progress, 3.06 feet.

In running drift described in answer to No. 3, six-hour watches, with three men per watch, were employed. Average daily progress, 3.578 feet.

6. The cost of raising ore, water, &c., from various depths.

Estimate of cost of raising ore from a depth of 1,750 feet, (level of the Sutro Tunnel,) with the machinery now in use. Size of cylinder of hoisting engine, 18 inches by 27 inches.

This estimate is based upon the following proposition: That two reel-shafts be coupled into one, running one cage up and one down at the same time; machinery being geared so that speed of the cage in the shaft is 800 feet per minute; double-deck cages being used, hoisting two cars at a time, each car containing 1,500 pounds of ore. Estimated to make six trips per hour, inclusive of all necessary stoppages or delays occasioned by lowering and hoisting men, and lowering timbers into the mine, and all necessary delays for repairs:

Engineers' wages, per day	$10 25
Foremen's wages, per day	4 00
Wood-haulers' wages, per day	2 50
Three cords wood per day	30 00
Tar for ropes and oil for machinery, per day	2 00
Scaling boilers, per day	1 00
Wear and tear of machinery, per day	5 00
Interest on cost of machinery, $28,000, at 1 per cent. per month	9 20
Total amount	63 95

Total cost per day for hoisting 216 tons of ore 1,750 feet, $63 95, or, 29.6 cents per ton.

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7. The cost of pumping at your mine for twelve months, preferably for the year ending June 30, 1871.

Actual cost of pumping 700 feet, for the year ending May 31, 1871.

Labor:		
Pitman's wages	$2,007 50	
Engineers and firemen	5,309 50	
Wood hauler	703 00	
		$8,020 00
Fuel:		
1,387 cords of wood, at $12	16,644 00	
27¾ tons of coal, at $20	555 00	
		17,199 00
Oil and tallow:		
Lard and other oils	215 67	
1,315 pounds of tallow	162 37	
		378 04
Interest on cost of pumping-machinery, $31,000, at 1 per cent. per month		3,720 00
Total cost		29,317 04
Value of water raised		8,975 00
Net cost of raising water		20,342 04

Amount of water raised during the year ending May 31, 1871.

Monthly average of daily measurements:

1870.		
June.	18 inches.	Present flow of water September 10, 1871, 5 inches.
July.	16 inches.	
August.	11 inches.	
September.	11 inches.	Decrease in amount of water at 700-foot level, from June, 1870, to date, 72.23 per cent.
October.	10 inches.	
November.	10 inches.	
December.	10 inches.	
1871.		
January.	9 inches.	
February.	9 inches.	
March.	9 inches.	
April.	8 inches.	
May.	7 inches.	

The above measurement is what is termed on this coast "Miner's measurement," the water running under a six-inch pressure.

13. At what depth will the present machinery be available for hoisting the ore or clearing the mine from water?—Hoisting machinery, 2,500 feet; pumping machinery, 1,500 feet.

16. What has been the expense of prospecting the mine for the year passed?—Total mine expense for the year ending August 31, 1871, $140,571 87. All work being of a prospecting nature.

Should any of the foregoing answers require explanation, I shall be pleased to furnish the same at your request.

Very respectfully, your obedient servant,

H. H. DAY,
Superintendent Ophir Silver Mining Company.

H. G. WRIGHT,
Brevet Major General and Senior Officer Sutro Tunnel Commission.

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APPENDIX D.

GOULD & CURRY.

SUPERINTENDENT'S OFFICE, GOULD & CURRY SILVER MINING COMPANY,
Virginia, Nevada, September 2, 1871

GENERAL:—In accordance with your request, I herewith inclose answer to your interrogatories of 28th of July.

Yours, respectfully,

C. C. BATTERMAN.
Superintendent Gould & Curry Silver Mining Company.

H. G. WRIGHT,
Major General, Senior Officer Sutro Commission.

No. 1. The value of the bullion extracted from the Comstock lode?

Answer. The value of the bullion extracted from the Gould & Curry mine up to and including June 30, 1871, is $15,555,232 24.

No. 2. The present and probable future production?

Answer. Present production nothing—the future, dependent upon the success of the explorations now in progress.

No. 3. The geological and practical value of said tunnel as an exploring work?

Answer. Geologically, it would, no doubt, be of value to the scientist. To the Tunnel Company it would be of great value as determining the existence or otherwise of ore deposits within the bounds of its land grant, and to the eastward of the explorations made by the mining companies at work upon the Comstock lode. To the Comstock it would be of no practical value. The advantages of ventilation supposed to accrue from the construction of the tunnel are more imaginary than practical. The current of air supposed to be created by the connection of the tunnel with the working drifts of the various mines will, no doubt, be confined to the main drifts and shafts, while the stopes—which are the working points in all mines—will have to be furnished with air then as now, by artificial means, which can be done by air-engines much more cheaply through the present shafts than through the proposed adit.

The economy claimed over the present method in bringing the ore to the surface is entirely imaginary; that I assert this advisedly, allow me to call your attention to the table in answer to supplemental question No. 6—to the accuracy of which I am willing to certify. The cost of "chuteing" the rock from any point in this mine, say 500 feet above the level of the proposed tunnel, would be greater than to raise the rock to the surface from that depth through the shaft where it would be in dump ready for transportation, while after delivery by "chute" to tunnel level there would still remain four miles of transportation to reach the surface at the mouth of the tunnel, where the ore would be at a greater distance from the reduction works than when in the dump at the top of the shaft.

In this connection, allow me to call your attention to the fact that there is a considerable quantity of low-grade ore remaining in this mine that cannot be worked now with profit, but which, at a lower cost for reduction and material, can be extracted with a moderate profit to the mine; but if to this is to be attached a royalty, I fear the day is still far distant when it shall be made available.

The average value of the ore extracted from this mine in 1868—and which was selected from the reserve just mentioned—was $18 14 per ton, at a cost of $16 35 per ton for extraction and reduction; if to this cost had attached the proposed royalty, the result would have been a loss to the company. Some of the other mines on the Comstock have a greater quantity of this class of ore than the Gould & Curry, and as an illustration of the meager margin of profit I beg leave to call your attention to the report of operations in the Savage mine for the year ending June 30, 1871, when the average profit for the year on ore extracted was 42 cents per ton, the gross yield being $21 43 per ton.

The tunnel, if of any value at all to the Comstock, would be as a drain-tunnel, though even this proposition is a matter of doubt, the explorations on the lode all going to show a decrease of water with increase of depth attained.

From careful estimates, I am satisfied that in this mine 6,500 gallons of water per hour can be raised from a depth of 2,000 feet at a cost of $84 per day; from this should be deducted the value of the water, which, at present rates, would be about $1,000 per month, leaving the cost of pumping $1,520 per month of thirty days; this on the amount of ore produced last year, 24,305 tons, would amount to 75 cents per ton: add to this the cost of raising rock from same depth, 71 cents per ton, and we have a total cost for rock and water of $1 46 per ton, or 27 per cent. less than the proposed royalty.

If the yield of ore should be equal to the capacity of the machinery at a depth of 2,000 feet, 194 tons per day, the cost of pumping water and raising ore would be $1 07 per ton, or 50 per cent. less than the proposed royalty, and only equaling the proposed toll of 25 cents per ton per mile.

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Supplemental questions.

No. 1. Cost, at various depths, of sinking shafts, estimated by the cubic foot removed, or by the running foot, for a shaft of given dimensions.

Answer. Size of shaft, 13 feet 2 inches by 8 feet 10 inches.

Cost of labor for running foot	$48 86
Cost of keeping tools in repair	1 97
Cost of powder, fuse, &c	7 36
Total	58 19

The above is the actual cost of sinking 109 feet in this mine, commencing 1,191 feet from the surface and terminating at 1,300 feet. The rocks passed through were quartz and porphyry, the former predominating unusually hard, consequently the progress was very slow and the work exceptionally costly.

No. 2. The present cost of timbering same, with the increase, if any, with the depth.

Answer. Size of timber used, 12½ by 14 inches; lagging, 3-inch plank.

Cost of timber, &c., per foot in depth	$8 84
Cost of labor framing	2 00
Total cost per foot in depth	$10 84

The cost of labor in placing the timbers in position is included in the cost of labor for sinking. No material increase of cost with increase of depth.

No. 3. The cost of drifting in the various rocks met with in your operations, estimated either by the cubic foot or by the running foot, specifying the dimensions of the cross-section.

Answer. The following is the actual average cost per running foot of two drifts run in this mine during the year 1870. I have selected these two for the reason that they were of the greatest length, and the work was prosecuted uninterruptedly, affording a fair average as to progress and cost.

Eldorado Potosi drift, 101 feet below the surface, 480 feet in length, running obliquely across the stratification, 44 feet hard-blasting porphyry, 30 feet clay, 80 feet of quartz, 326 feet of porphyry, that was worked with pick. Size of drift outside of timbers, 8 feet high, 5 feet 9 inches wide at top, 6 feet 10 inches at bottom; inside of timbers, 6 feet 3 inches, 3 feet 6 inches, and 4 feet 8 inches. The cost of placing timbers in position included in cost of running drift.

	Per foot.
Average cost of 44 feet	$8 00
Average cost of 436 feet	5 00

Seventh-station dritt, 1,167 feet below surface, 600 feet in length, running obliquely through heavy clay and hard porphyry. Size outside of timbers, 8 feet 10 inches in height, 3 feet 9 inches wide at top, 6 feet 9 inches in center, 5 feet 10 inches bottom. Inside size, 6 feet 4 inches, 2 feet, 3 feet 10, and 3 feet 6 inches. Average cost per running foot, including placing of timbers, $8 10. In this drift the clay, by swelling, was continually displacing the timbers, which had to be eased by cutting away behind them; in many instances we were compelled to use jack-screws to force them back to position, which makes the average cost of this drift more than it would otherwise have been.

No. 4. The cost of timbering the same.

Answer. The Potosi drift, timbered in square-tunnel sets, size of timber 8 by 10 inches, and 3 by 6 inch lagging; sets placed 5 feet apart; cost per running foot, including framing, $1 89.

Seventh-station drift, size of timber used 14 by 14 inches, framed in arch plank lagging; sets placed 5 feet apart; cost per running foot, including framing, $4 90. The cost per running foot, timbered in square sets, would have been $4 76.

No. 5. The daily progress made in the shafts and drifts through the various rocks, the largest force that can be worked to advantage being employed.

Answer. In sinking shaft from seventh to eighth station, that is, from 1,167 to 1,300 feet, the excavation has been entirely within quartz and porphyry, the former predominating and exceedingly hard, as is evidenced by the quantity of powder used. The average progress was 18 inches in depth per twenty-four hours. Twenty men employed; four shifts of five men six hours each. In such rock as was generally found above the 1,167 level the same force would have made about 3 feet each twenty-four hours. In Potosi drift the formation being hard porphyry, soft porphyry, clay, and quartz of average hardness, the drift running obliquely across the formation, the average progress was, through the former, hard porphyry, 4 feet per day, twenty-four hours. Eight men employed; four shifts of two men six hours each. In seventh-station drift, 600

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feet in length, formation heavy clay and hard porphyry drift crossing the strata obliquely; the average progress was 3 feet in twenty-four hours. Six men; three shifts of eight hours.

No. 6. The cost of raising ore, water, &c., from various depths.

Answer:

Depth from surface.	Capacity of machinery per 24 hours.	Cost of fuel per ton.	Cost of labor, repairs, and all other expenses.	Total cost per ton.
Feet.	*Tons.*	*Cents.*	*Cents.*	*Cents.*
400	1,000	07.08	05.84	12.92
800	750	12.09	09.5	22.4
1,300	408	23.1	18.9	42
1,400	367	25.41	19.87	45.28
1,500	330	27.95	20.84	48.79
1,600	297	30.74	21.81	52.55
1,700	267	33.81	22.78	56.59
1,800	240	37.19	23.75	60.94
1,900	215	40.90	24.72	65.62
2,000	194	44.99	25.69	70.68

The engines work independently, that is, each engine hoists and lowers separately. If the engines were geared together, so that when one cage was being hoisted the other was lowered, the cost per ton would be considerably reduced.

In the above table of cost is included wood, water, $600 per month, oil, engineers, firemen, boiler-cleaner, woodman, and average cost of keeping machinery in repair.

The cost of raising the water in this mine from a depth of 825 feet, also running pump while sinking to 1,300-feet station has been $60 per day, the quantity of water raised about 3,500 gallons per hour.

The capacity of the pumps is 6,500 gallons per hour. I estimate the cost of pumping from a depth of 2,000 feet, working pump to full capacity, at $83 60 per day. This estimate includes wood, engineers, fireman, pitman, &c. From this estimate of cost should be deducted the value of the water.

No. 7. The cost of pumping at your mine for twelve months, preferably for the year ending June 30, 1871.

Answer:

Cost for the year	$16,425 00
Deduct water sold	6,000 00
	10,425 00

No. 8. Has the water in your mine increased or diminished with the depth, and in what proportion?

Answer. The greatest quantity of water in this mine was found above the sixth level from the surface to a depth of 825 feet; from this point downward the quantity of water is very small.

At the eighth station 1,300 feet from the surface the lode is practically dry; were it not for the seepage from above, which finds its way down the shaft, working at this depth could be prosecuted without the aid of pumps.

I beg to call your attention to the fact that in this mine no considerable bodies of water have been encountered except when the country to the west of the lode has been penetrated.

No. 9. The cost per ton of ore for milling, and when the cost of the transportation to the mill is included the cost of the latter.

Answer. The ore from this mine has been delivered to the mills at the dump. The price paid for milling, which included transportation, was $12 per ton.

No. 10. What is the present cost of the artificial ventilation of your mine, and how does it increase with the depth.

Answer. The cost of ventilation by Root's blower, carrying the air down the shaft through wooden tubing and distributing it through the drifts by galvanized pipe, is $9 35 per day, furnishing air to all the drifts from 625 feet below the surface to 1,300 feet. No increase of cost with increase depth, except the cost of continuing tubing down the shaft.

No. 11. How long a time, at the present progress of working, will it require to exhaust all the profitable ore in the mine above the 600-foot level?

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Answer. There is no known body of ore existing above the 600-foot level that could be profitably worked at the present cost of reduction, &c.

No. 12. How long between the 600 and 1,000 foot level?

Answer. No paying ore has ever been found in this mine below 600 feet.

No. 13. At what depth will the present machinery be available for hoisting the ore, or clearing the mine from water?

Answer. Two thousand feet.

No. 14. See answers to Nos. 6 and 7.

No. 15. What is the width of the lode, and also of productive vein-matter, at the various levels of your mine?

Answer. The width of the lode is undetermined. The productive portion of the lode had an average width of 40 feet from near the surface to a depth of 525 feet below (A); below this depth ore has not been found in paying quantity.

No. 16. What has been the expense of prospecting the mine for the year past?

Answer. For the year ending June 30, 1871, $193,670 92.

No. 17. How does the pay-ore compare at each level, from the surface downward?

Answer. That taken from near the surface was the most valuable.

All the measurements of depth given in these answers are from top of shaft, except that to No. 15, which is from station A, King's map. To make measurements correspond with those used in the Sutro map, 200 feet should be added, that being the difference in level between shaft and station A; thus, our eighth station, which I designated as 1,300 feet, would be 1,500 feet on Sutro survey.

C. C. BATTERMAN,
Superintendent Gould & Curry Silver-Mining Company.

VIRGINIA, NEVADA, *September* 2, 1871.

APPENDIX E.

SUPERINTENDENT'S OFFICE, SAVAGE MINING COMPANY,
Virginia City, Nevada, September 16, 1871.

DEAR SIR: The value of the bullion extracted from the Savage mine during the year ending June 30, 1871, was $818,216 50. From the want of the necessary data I am unable, at the present time, to state the value of all the bullion extracted from the mines on the Comstock lode from the time they were first opened, or during the past year.

Not a small portion of last year's production in bullion came from the tailings which had accumulated at mills in former years, and from the remnants of ore bodies left from the old workings in the upper levels of the mine.

From a general view of the present condition and prospects of the mines on the Comstock lode taken together, I do not anticipate any material change for the next year or two from the last year in the amount of bullion which will be produced. Any increase must depend entirely upon developments which cannot now be foreseen.

The practical value of the Sutro Tunnel as an exploring work can only be a matter of conjecture. In the ground which it traverses it may or may not develop important veins of ore. In this respect it stands on even footing with the numerous similar enterprises on a smaller scale which have been carried on in California and in this State. In a geological point of view the discoveries on the route of the tunnel may give much interesting and valuable information. But I am unable to see what practical good any geological development made outside can be to mining within the limits of the Comstock lode. The attempts made by experts in former years to apply the rules and principles of geology in determining the extent, boundaries, and value of the vein proved entirely futile. With practical miners the pick and shovel have come to be recognized as the only reliable experts within the limits of the Comstock lode.

In regard to the value of the Sutro Tunnel as an aid to deep mining on the Comstock lode, my own individual opinion has been formed from a few simple facts, and not from any desire to establish any particular theory which has to be supported by an array of figures and statistics. The chief purposes urged, as I understand, for carrying on this work are drainage, the cheaper extraction, and the cheaper reduction of ore. Until experience proved the contrary, it was a prevalent supposition, even among our leading mining men, that, by tapping the lead at one point, the whole vein would at once be drained down to the level of that point. This idea is exploded. The vein matter of the Comstock is intersected in various directions, longitudinally, crosswise, and diagonally, with clay seams impenetrable to water, and within the sections of a single mine thus bounded by clay seams or walls is confined more or less water, and a mine cannot be said to be drained until every one of these seams has been reached by drift and has been penetrated. Suppose this tunnel, as proposed, should be completed up to the east edge of the lode at the Savage mine, connections between this tunnel at that point and the several mines for the purpose of drainage would render

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necessary the running of tunnels for that specific purpose at an immense cost to the mines. The Crown Point and Belcher, two of the most productive mines in Gold Hill, could only be reached by a tunnel nearly one mile long. In the opposite direction to the north it would require a tunnel about a half mile in length to reach the Ophir.

Down to a level with the Sutro Tunnel, I consider that our present mode of extracting ore through shafts directly over the mines, and by machinery, will be the most direct, expeditious, the cheapest, and that by some addition to the present power the machinery will be amply sufficient to drain and to extract ore down to the level of that tunnel, and even beyond that depth, and that all this will be accomplished before the Sutro Tunnel can, in any reasonable probability, be completed up to the Comstock lode.

If it be contemplated by the projectors of this tunnel, as one of the objects of the enterprise, to have the ore taken out through this tunnel and deposited near the mills to be reduced by water-power in mills to be erected, I would reply, in answer to this view of the case, that a large portion of the ore is now being transported to mills already in operation on the river, over a convenient and substantial surface-railway, instead of being drawn four miles under ground by man or horse power. As to the necessity or advantage of such a tunnel to aid in the working of the mines below its (the tunnel's own level, so little is known of the extent of the lode downward, and there are so many uncertainties connected with it, that it seems like making a costly provision for objects which may not eventually require its construction, even if the present means of hoisting and pumping were not sufficient to work below that level. The above views, formed from long and mature consideration, are respectfully submitted by

Your obedient servant,

T. B. SHAMP,
Superintendent Savage Mining Company.

Major General H. G. WRIGHT,
Senior Officer of Sutro Tunnel Commission.

OFFICE SUTRO TUNNEL COMMISSION,
Virginia City, Nevada, July 28, 1871.

Answer to question 1. Dimensions of shaft are 28 feet by 8 feet; average cost of sinking, 42 per running foot.

Answer to question 2. Present cost of timbering shaft, at the depth of 1,300 feet, is per running foot. No material increase in this cost for the next few hundred feet.

Answer to question 3. Cost of drifting in the various rocks from $6 to $24 per running foot; average cost on the 1,300-foot level, $10 per running foot. Dimensions of cross-sections of drifts, 7 feet high, 6½ feet wide at the bottom, and 4½ feet wide at the top.

Answer to question 4. Cost of timbering drifts $1.58 per running foot.

Answer to question 5. Progress in sinking shaft averages 1 running foot per day; progress in running drifts, from 1 to 5 feet running per day, according to the character of the rock.

Answer to question 6. Cost of raising ore from the 1,300-foot (or lowest) level, $1 per ton.

Answer to question 7. Cost of pumping for the year ending June 30, 1871, $22,157. The present flow of water is 19,116 gallons in twenty-four hours.

Answer to question 8. The flow of water on the 1,300-foot (or lowest) level is somewhat less than it was on some of the levels above. The proportion in which it has diminished cannot now be accurately ascertained.

Answer to question 9. The average cost of milling ore for the last year has been $15 per ton, average. This includes transportation, which costs from 75 cents to $3 per ton according to the distance.

Answer to question 10. The present cost of artificial ventilation of the mine is about $12 per day.

Answer to question 11. Six months' time, at the present rate of working, will exhaust all the profitable ore in sight above the 600-foot level.

Answer to question 12. Six months' time will also exhaust all profitable ore in sight between the 600-foot and the 1,000-foot level.

Answer to question 13. The depth of the present lowest level is 1,300 feet. The present machinery will be available for hoisting ore from a depth 400 feet below this level, and for pumping the mine 1,500 feet deeper.

Answer to question 14. The chief additional expense of hoisting ore, and pumping from a depth 1,000 feet below the 1,000-foot level, will be the extra steam-power required, and that is estimated to be but a small fractional proportion of the power required in hoisting and pumping from the 1,000-foot level.

Answer to question 15. The width of the productive vein-matter on the several levels which have been worked has varied from 4 feet to 40 feet.

Answer to question 16. The expense of prospecting the mine for the year ending June 30, 1871, was $116,371.

Answer to question 17. The value of the ore per ton has diminished from the upper levels downward.

T. B. SHAMP,
Superintendent Savage Mining Company.

VIRGINIA CITY, NEVADA, *September* 16, 1871.

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APPENDIX F.

OFFICE HALE & NORCROSS'S SILVER-MINING COMPANY,
Virginia, October 3, 1871.

DEAR SIR: In reply to your printed circular, received last month, I will state to questions Nos. 1 and 2: The size of our main shaft is 6 feet wide and 18 feet long, divided into three compartments. The cost of sinking this shaft has been $23.25 per foot, and of timbering the same $16.50 per foot, and, from the limited quantity of material possible to be excavated from a piece of ground of those dimensions, (necessarily employing the hoisting power only a small part of the time, and not continuously,) the increase in cost of sinking the shaft has not been perceptible, particularly as water does not impede this work to so great an extent as when advancing downward near the surface.

Question No. 3. The average dimensions of our drifts and tunnels are 5½ feet wide and 7½ feet high. The average cost of running these drifts is $8 per foot.

Question No. 4. The cost of timbering these drifts is $2 per running foot.

Question No. 5. From 3 to 12 feet per day is the distance run in these drifts, according to hours worked and character of the material penetrated.

Question No. 6. The cost of hoisting ore from present station is 50 cents per ton, and has not greatly varied therefrom when extracted from the upper levels.

Question No. 7. For the year ended June 30, 1871, the cost of pumping water has been $2,320.

Question No. 8. The water to be pumped is less than when working nearer the surface; it is about one-sixth of the former volume.

Question No. 9. This company has paid from $9 to $12 per ton for milling its ores. (The mills pay their own transportation, which has been from 65 cents to $1.10 per ton.)

Question No. 10. As yet no increase in cost of ventilating the mine is noticed; the expense has averaged us $4 per day.

Question No. 11. About five years.

Question No. 12. About three years.

Question No. 13. To a depth of 2,500 feet this company has nearly completed the placing of ponderous machinery to aid in the prospecting of the mine at greater depths. We have no ropes of that length yet, but will have them made long before required. Our reels are adapted to such lengths, (being flat-steel wire-ropes.)

Question No. 14. To a depth of 500 feet below our present lowest level (called the 1,300-foot level) no particular augmentation of expense will be necessary. For a greater depth I cannot at present state.

Question No. 15. The width of our pay-vein was, at 100 feet in depth, 90 feet; 200 feet in depth, 80 feet; 300 feet in depth, 50 feet; 1,200 feet in depth, 45 feet; 1,300 feet in depth, 80 feet.

Question No. 16. Our prospecting expenses for the year have been $147,000.

Question No. 17. The pay-ore lessens in value as we descend. It then increases in value, and again lessens to a still greater extent.

Very respectfully, yours, J. G. FAIR, *Superintendent.*

Mr. H. G. WRIGHT, *Army Building, New York.*

APPENDIX G.

OFFICE CHOLLAR POTOSI MINING COMPANY,
Viginia City, Nevada, September —, 1871.

RESPECTED SIR: In compliance with your request made at this place I herewith submit the following as answers to the various questions contained in your circular bearing date at Virginia City, Nevada, July 28, 1871:

CONGRESSIONAL QUESTIONS.

Question No. 1. Value of bullion extracted from mines on the Comstock lode.

Answer. Total amount of bullion extracted from this mine is $11,772,105.47.

Question No. 2. Their present and probable future production.

Answer. For the twelve months ending May 31, A. D. 1871, the average monthly yield of bullion was $288,285.25. For the months of June and July following the bullion production averaged $166,312. The future yield of bullion necessarily depends on the success of prospecting. At this writing indications are positively and decidedly against the hope that any twelve months in the future will nearly equal the production of the past year.

Question No. 3. The geological and practical value of said tunnel as an exploring work.

Answer. *Geologically*, science may derive information of value to students in that branch of learning, although the probabilities strongly favor the opinion that the same geological knowledge can be acquired more easily and at vastly less expense. *Practically* considered, after many years' experience in mining—five of which have been exclusively devoted to the "Comstock lode," in directing and superintending mining

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operations—being thus employed, opportunities were abundant to gain a knowledge of the formations and to study the nature of the various deposits that make up the lode. Also, to satisfactorily determine water-sources that have supplied the subterranean reservoirs met with in explorations along this vein.

The result of this experience dictates the following conclusions: That the proposed adit known as the "Sutro Tunnel" is not now, and never will be, a necessity to the lode, either for prospecting purposes, ventilation, or for the economical handling of metal-bearing material, waste or *débris*, or as a means of entry or exit for men to the various mines located on the "Comstock." The reasons why said adit is not necessary for prospecting purposes: This company have a shaft and incline sunk immediately on the lode to the vertical depth, from top of shaft, of 1,250 or 1,418 feet from point [A] as designated on Clarence King's atlas of Mining Industry. The shaft is located near the center of this company's claim; that is, so far as a north and south line is considered. For a better understanding of the location of the shaft, and the explorations carried on from the same, reference is hereby made to the atlas mentioned above. From this shaft explorations have been, and always can be, carried on with far greater economy, more safety, and in a more satisfactory manner than could be done through the proposed adit, owing to the fact that the shaft, being on and passing through the lode we have our entire operations, as it were, in a "nut-shell." Stations are made at every hundred feet in depth; from these, drifts are driven running north and south, east and west, or at any other point of the compass desired. From these drifts, as they are pushed on, we can and do gather daily information of the value of material passed through; the condition and prospect of the lode for the next level. Through this shaft we pass our men to the various sections of the mine allotted to them. Down here goes all the timber used in all portions of slopes, drifts, and winges, also the tools; in short everything needed for the perfect working of the mine. By aid of machinery at the surface all of this work is done. Allow me to ask how would it be to run in timber two miles through a tunnel, and hoist the same up seventeen hundred feet vertically, as we would be compelled to do—this company having done no work for two years last past below the 200-foot level of their shaft—and from there distribute them through the mine. Presuming we were down on the 1,000-foot level extracting ore, as this tunnel, as is proposed, the means of entry and exit for ore, men, and timber we would then be compelled to hoist our timber 800 feet by hand—as the projector of the tunnel assumes that no machinery is required to operate the mines after the tunnel is complete—and the poor toiling miner must climb up by sheer muscle-power the same distance. Imagine, if you can, hundreds, ay, thousands of men climbing up and down these vertical ladders distances varying from five to seventeen hundred feet, and then compare it with the ease and safety that they are placed at the various stations in the shaft by the aid of machinery we now have in use at our mine; and does it not comport with good economy to spend the muscle-power at the face of drifts and in the stopes, rather than exhaust the energies of your men climbing up and down immense vertical heights on ladders? Hence I assert, without fear of successful contradiction, that for the purpose of exploring this lode the proposed tunnel would prove a positive failure.

Concerning the country east of the Comstock, and through which this proposed adit is supposed to pass, I claim no knowledge. All reasoning on what exists at great depths east must necessarily be theoretical. My conclusions are that, at the depth this proposed tunnel would come, no precious metal exists outside of the main vein. Some prominent croppings eastward have been operated on most of the time during the last eleven years. The few hundred feet in depth that have been attained on them resulted in practically exhausting the extremely limited amount of precious metals, and in nearly every instance has been the financial ruin of those interested.

To illustrate the supposed benefits to be derived from this proposed tunnel for ventilation, we will assume that the same is completed along the whole line, and connected with each shaft—a bold assumption, I grant—the currents of air supposed to be passing rapidly through the tunnel and shafts, with all this imaginary air passing through these funnels, not a particle can be had at the stope we are working 700 feet west, as is the case in this claim, of the shaft. To get air in a stope or drift away from the shaft machinery must be used. All practical miners are aware of this fact, consequently the applying of compressed-air machinery for ventilating these mines, and using the engine in deep levels to hoist with is being considered, and will, no doubt, if the prospects of the lode justify, be soon put in operation. With this machinery, and a connection of the various shafts, a more perfect system of ventilation will be secured than any other method can afford, and at an expense that would be considered as nothing when compared with the expense attending the very imperfect manner of ventilation as proposed by the owners of the "adit franchise."

Handling of ore.—Please, sir, come with me and examine the matter of passing the ore that this company is now mining, or ever has mined, through this proposed tunnel. We start at the mouth of this company's shaft, and go down 178 feet; here is the station. We leave the shaft, and go in west 16° south for 700 feet; here we are under where the large body of ore known as the Belvedere existed. North of us to the

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company's north line, and down below us 280 feet, making 458 feet in depth from mouth to shaft, is the section of country from which all the ore has been taken that produced the nearly $12,000,000 in bullion mentioned in the beginning as the gross product of the mine. Below this 458-foot level, we have gone 800 feet without finding ore, and as we attained depth the more discouraging our prospects became. That is why two years have passed without our making an effort to sink further. Had even the slightest encouragement been developed, we should have continued the sinking, and would have been at this date 300 feet below the level of the proposed tunnel.

Pardon this digression. Let us return to the point 700 feet west of the shaft, and consider the proposition of running this ore from here to the shaft, and dumping the same down a chute 2,000 feet in length. Why so long? Because the chute must be on an angle of 45° to conform to the west wall, and to reach the tunnel from this level at the shaft. Can a chute be made to work that distance and on that angle? We practical miners would promptly say, no, sir; as we find it very difficult to maintain chutes 300 or 400 feet in length standing vertical. Do we ever make them on angle? Never at 45°, and never on any angle if we can avoid it, as they clog and wear much more quickly than vertical ones. Sir, permit me to ask, would you not consider us guilty of the most consummate folly to chute this ore down 2,000 feet (if it could be done) to this proposed tunnel, and run it out four miles for the privilege of hauling up heavy hills to mills, when we can run the car loaded with ore on the cage, hoist to the surface, 178 feet, place the ore in dumps made purposely to facilitate the loading of railroad cars or teams, and from this point the hauling is all the way down hill? What does it cost for hoisting from this level? During the month of July we hoisted 3,000 tons from here, drove the engine to run the blower for ventilating the drifts. To make steam necessary for this work ten cords of wood were consumed, or one-third of a cord each twenty-four hours. As, you will notice, one car goes up, the car in the next compartment of the shaft comes down. This arrangement makes hoisting easy, also very economical, and can be made to work equally well 2,000 feet in depth as it does here at 200 feet. Fact is, the matter of hoisting from any depth up to 3,000 feet can be easily accomplished. How to get the ore out from these deep levels is not the important question on the Comstock. To find the ore to hoist, that is where the insurmountable difficulty comes in. To solve that problem requires more brain, muscle, and money than all other operations along the vein put together. Show us the ore, even at the depth of 3,000 feet, and I will give you a pledge, sir, that we will never ask how shall we get this ore out. Relative to this proposed adit as a means of entry and exit for men, the remarks already made are perhaps quite sufficient on that point. In brief, the whole tunnel project is simply impracticable, unnecessary, and totally uncalled for except as a drain. Here a few words will be applicable concerning the water-source and subterranean reservoirs that have been met with. All water found in this mine has been in reservoirs; these were formed by the clays uniting, so that in shape they represented huge basins. The water-supplies came from the surface. Melting of snows for thousands of years formed the water which percolated to and filled these reservoirs. Prospecting drifts pierced the clays and tapped these water deposits, and drained them, at the various stations, until the clays reached the west wall, which terminated the reservoirs. Below the 1,000-foot level in this mine water was not met with. On the 1,250-foot level there was no natural moisture. The Bullion claims, first adjoining us on the south, reached in depth 100 feet below our 1,250-foot station. At that point the earth was so intensely dry that dust caused from the working pervaded the drift, very much to the discomfort of the miners in said drift. If, in review, these facts are given their proper weight, the conclusions naturally follow that the construction of an immense adit to drain the Chollar Potosi mine would be superfluous.

To the best of our knowledge we have made answer to the congressional questions. We next proceed to answer those interrogatories propounded by your honorable body.

COMMISSION QUESTIONS.

Question No. 1. Cost, at various depths, of sinking shafts estimated by the cubic foot removed, or by the running foot, for a shaft of given dimensions?

To give answer to this I will take the main incline, which commences at a point 891 feet down from mouth of shaft, and continues down on an angle of 45° to the east, a distance of 612 feet, at which point is our deepest level. Size of excavation is 14 feet in width, 9 feet in height. This excavation, as timbered, forms two compartments. The one on the pump side is 6 feet in height, in clear of timbers, by 6 feet in width, in clear of timbers. The other, the hoisting compartment, is 6 feet in height by 4 feet in width.

Excavation cost per running or lineal foot	$20 00
Timber, 200 feet, at 2½ cents per lineal foot	5 00
Timber framing and setting, per lineal foot	5 00
Wear and tear of machinery, oils, and incidentals	5 00
Total cost per running or lineal foot	35 00

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These figures represent the average cost per lineal foot for running said incline from the beginning to the completion, or the entire length of 612 feet. Had we taken down other two compartments to correspond with the main or vertical shaft, the expense would not have been so great proportionally. Material passed through was syenite.

Question No. 2. The present cost of timbering the same with the increase, if any, with the depth.

Answer to this question was merged in the answer made to No. 1, except "the increased cost of timbering as depth is attained." Practically speaking there is no increase in the cost.

Question No. 3. The cost of drifting, in the various rocks met with in your operations, estimated either by the cubic foot or by the running foot, specifying the dimensions of the cross-section.

Answer. In answering this question I will take as an example our drift at the 178-foot station, the same that you passed through when you visited the mine. The drift is 700 feet in length from shaft to Belvedere country. In making the drift all the material common to this section outside of the lode was passed through, such as andesite, quartzite, porphyry, and clay. The following figures show the cost per running or lineal foot:

	Per foot.
Running drift by contract, contractors furnishing candles	$3 75
Timber and framing	1 85
Sharpening tools	1 00
Hoist and deposit earth	3 00
Total cost per foot	9 60

Size of drift outside of timbers is 6 feet 6 inches by 9 feet 5 inches by 5 feet 6 inches (6 feet 6 by 9 feet 5 by 5 feet 6.) A diagram of shape and size of timber in drift was handed you. With your consent I make reference to said diagram to show size of drift in clear of timber.

Question No. 4. The cost of timbering the same.

Answer. As noted above, the timber and framing cost $1 85 per lineal foot. The putting of them in place was included in the contract for running.

Question No. 5. The daily progress made in the shafts and drifts through the various rocks, the largest force that can be worked to advantage being employed.

Answer. In drift from shaft at 178-foot station the average progress was 6 feet 6 inches—6½ feet each twenty-four hours. In sinking the incline, average progress was 4 feet 8 inches each twenty-four hours. At both the incline and drift all was done that could be to hasten progress.

Question No. 6. The cost of raising ore, water, &c., from various depths.

Answer. At the 1,250-foot station material was taken up the incline, placed on the cages in shaft, and taken to the surface for an actual cost of 38 cents per ton. Had we succeeded in finding ore there in sufficient quantities to have kept the machinery steadily employed, 35 cents per ton would cover the cost of hoisting. The water quantity was so limited when we were operating in low levels that for weeks together the pumps would run one hour only out of the twenty-four. No record was kept of that expense.

Question No. 7. The cost of pumping at your mine for twelve months, preferably for the year ending June 30, 1871.

Answer. For two years last past this mine has been entirely exempted from pumping.

Question No. 8. Has the water in your mine increased or diminished with the depth, and in what proportion?

Answer. As depth was attained water diminished; at the lowest level there was no water.

Question No. 9. The cost per ton of ore for milling, and, where the cost of transportation to the mills is included, the cost of the latter.

Answer. For the year ending May 31, 1871, this company paid $12 per ton for the milling and transportation of their ore. What the cost of transportation was I know not.

Question No. 10. What is the present cost of artificial ventilation of your mine, and how does it increase with the depth?

Answer. The points ventilated in this mine artificially at this time are three; expense attending same is 75 cents per day. The cost of ventilation at the deepest levels was $6 per day.

Question No. 11. How long a time, at the present progress of working, will it require to exhaust all the profitable ore in the mine above the 600-foot level?

Answer. At present rate of working, three years' time will exhaust all the ore in the mine; that is, all the ore that is known to exist.

Question No. 12. How long between the 600 and 1,000-foot levels?

Answer. Up to this date no ore worthy of mention has been found below the 600-foot level.

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Question No. 13. At what depth will present machinery be available for hoisting the ore or clearing the mine from water?

Answer. Two thousand and two hundred feet vertically; that is, the machinery we had in use when the work at lower levels was being prosecuted would have been sufficient to have reached the distance above stated.

To question No. 14 answer will be omitted, for the reason that, all work at our lower levels being suspended, to attempt to make answer could be nothing more than guessing.

Question No. 15. What is the width of the lode, and also of productive vein-matter, at the various levels in your mines?

Answer. The width of the Comstock is a matter that is to-day entirely undecided. The productive vein-matter in this mine has averaged about 45 feet in width.

Question No. 16. What has been the expense of prospecting the mine for the year past?

Answer. For the year ending last 31st of May, $142,800 were expended in repairs, prospecting, dead work, and incidentals. About $100,000 of that amount was spent strictly for prospecting.

Question No. 17. How does the pay-ore compare at each level, from the surface downward?

Answer. The best ore produced by this mine, both as to quantity and quality, was taken out from the surface downward to the 300-foot level. Below that point the ore diminished in quantity and quality until it ran out.

Having concluded and made answers to the best of my understanding of your questions, I beg leave to say that should some of the answers prove to you vague, I will be most happy to make further explanation, if you will at any time, by letter or otherwise, signify your desire for such. Permit me to add further, that by referring to Clarence King's Mining Industry, or to the last Annual Report of this company, you may gather the information to make clear what may prove cloudy to you in some answers I have made.

I am, sir, very respectfully, yours,

ISAAC L. REQUA,
Superintendent of Chollar Potosi Mine.

Brevet Major General H. G. WRIGHT,
Senior Officer of Sutro Tunnel Commission.

EXPLANATION.

On folio 20 the cost of hoisting from the 1,250-foot level is 35 cents per ton. This work was done thirty months ago. At that time wood was $14 per cord; now the price is $10. Other expenses were larger then than now.

Beyond a doubt further reductions in cost of fuel will be made; also other expenses which will so far economize operations that 25 cents would cover the actual expense of hoisting per ton from the 1,250-foot level.

I beg your indulgence to express to your honorable committee my firm conviction concerning the utility of the proposed tunnel. If said tunnel, with the proposed lateral branches, was now complete, and the owners of the tunnel should sign a compact with the mine-owner agreeing to relinquish their right to collect royalty, also that the mine-owners should have the right of way through said adit to run ore timber, &c., and that tolls for use of said tunnel should not be collected, I am sure true economy would then be to hoist the ore by machinery to the surface as we are now doing.

Not wishing to exhaust your patience by dry figures to prove the above conclusions, I will simply say that proof abundant can be given to substantiate the assertion.

Respectfully, yours,

ISAAC L. REQUA.

OFFICE CHOLLAR POTOSI MINING-COMPANY,
Virginia, Nevada, July 21, 1871.

Gentlemen of the Sutro Tunnel Commission:

In reply to your questions concerning the cost of running the tunnel on the first station from new shaft of Chollar Potosi Mining Company west 700 feet, I beg leave to submit the following as the total cost per foot:

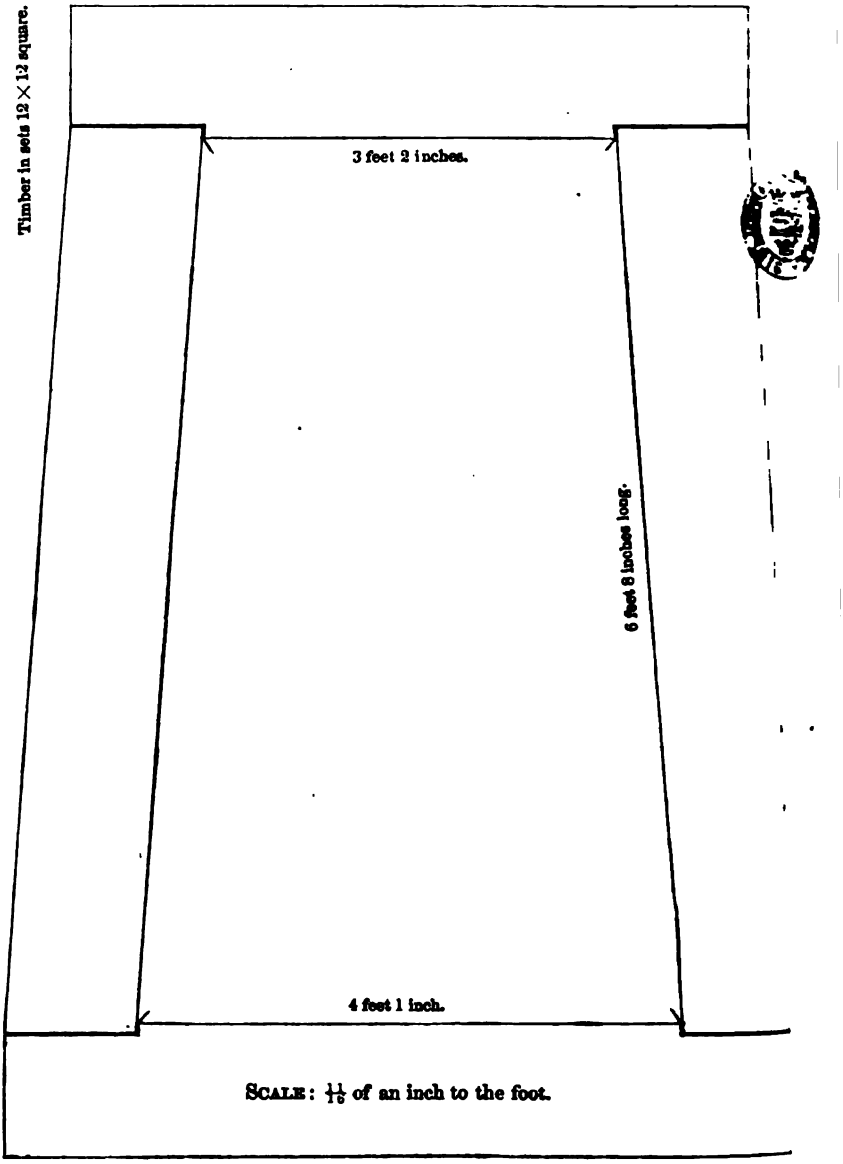
	Per linear foot.
Running drift by contract, contractors provide candles	$3 75
Timber and framing	1 85
Sharpening tools	1 00
Hoist and deposit earth	3 00
Total	9 60

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Size of drift outside of timbers is 6 feet 6 inches by 9 feet 5 inches by 5 feet 6 in...
The diagram connected gives the size in clear of timber.

Respectfully, yours,

ISAAC L. REQUA
Superintendent.



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APPENDIX H.

GOLD HILL, NEVADA, *October* 4, 1871.

DEAR SIR: The following are my answers to your various questions, which I have endeavored to answer as correctly as possible:

The Imperial and Empire shaft, 7½ by 20 feet outside of timbers, containing 150 cubic feet to each running foot, was sunk between the 1,200 and 1,300-foot levels for 36 cents per foot, all in very hard blasting rock, or 24 cents per cubic foot, including labor of timbering. This portion of the shaft was sunk in the vein where the quartz was very hard, and a large quantity of water to contend with. In good ground the same shaft can be sunk for 15 cents per cubic foot, including labor of timbering, or $18 90 per running foot.

No. 2. The cost to timber a shaft 7½ by 20 outside of timbers, for 100 running feet, will require 15,000 feet of 12 by 12 and 10 by 15, and 11,200 feet of plank, equal to 2½ feet of timber for each cubic foot of earth removed. Heavy ground will, of course, require more timber.

No. 3. The cost of drifting varies under so many different circumstances it is next to impossible to give a correct estimate. The size of our drifts, usually 6 by 9 outside of timber, with good cool air, can be run for $7 per foot in hard blasting ground. The same ground with thermometer 110° will cost $32 per running foot, or 59 cents per cubic foot.

No. 4. Cost of timbering the above drifts with sets 5 feet from centers would be $3 24 per running foot, or 6 cents per cubic foot.

No. 5. Daily progress in good air, 7 feet; thermometer 110°, 18 inches to 2 feet.

No. 6. The cost of raising ore, &c., from 1,300-foot level to the surface is 27 cents per ton; that is, running our present machinery full capacity. Estimated cost from 2,000-foot level, 50 cents per ton. This estimate includes every expense except wear and tear of machinery.

No. 7. The cost of raising the water for the past year is difficult to get at. Not having any pumps it was raised to the surface with a tank which we run only when absolutely necessary.

No. 8. See no perceptible change in water from 250-foot level to 1,300-foot level; if any, it has decreased.

No. 9. Company mill; cost of milling, $7 90, including hauling, which was 45 cents per ton.

No. 10. Cost of artificial ventilation: one Root's blower, $18 per day, carrying air to 1,340-foot level.

No. 11. All the available ore from the 600-foot level to the surface is exhausted, unless the cost of milling be reduced.

No. 12. From 600-foot level to our present lowest or 1,300-foot level, the vein in Imperial and Empire mines has been comparatively barren.

No. 13. Our present machinery in use at the mine will be available for hoisting to a depth of at least 2,500 feet.

No. 15. The width of the lode at the various levels varies; on 700-foot level the vein was 425 feet between walls; on 900-foot level, 308; on 1,300-foot level, 150 feet from east to west wall; productive vein-matter varies in width.

No. 16. The cost of prospecting for the year past was about $110,000.

No. 17. The pay-ore was quite uniform from the surface down to 700-foot level, where the vein had got to be so very wide and ore so scattered it could not be made to pay. The vein seems to be getting more concentrated as we go deeper.

Very respectfully, yours, &c.,

R. N. GRAVES,
Superintendent Imperial and Empire Mines.

Brevet Major General H. G. WRIGHT,
Sutro Tunnel Commissioner.

APPENDIX I.

GOLD HILL, *August* 31, 1871.

DEAR SIR: Your favor of 28th ultimo duly received, and all your questions noted and answered as follows, as concisely as possible with regard to accuracy:

The value of bullion extracted from the Yellow Jacket mine since date of incorporation in February, 1863, as per books of company, was.....	$12,772,172
Bullion from ore sold since the above date, and product of mine previous to the same, estimated at.....	1,500,000
Total amount of bullion.....	14,272,172

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The present yield of the mine is about $180,000 per month, or about $2,000,000 per year. The probable future yield will no doubt equal the past.

The geological value of the tunnel will consist in its showing a section of the country twenty-two thousand (22,000) feet east of the Comstock lode, a longer section than is probably shown by any similar work in the United States, and consequently of value to science. The practical value of said tunnel will be its use as an adit for the lode; as a means of ventilation it will be of value to any mine connecting its workings with the tunnel, but I think of no more value than the connections for air passages between the several shafts, as at present made. For the purposes of extracting ore above the tunnel level, it will be of very little value. We find that chutes over 150 feet in length are very expensive to keep in repair and open. Chutes of even that length are apt to become choked, when there is great danger and difficulty in clearing them, for which reason we seldom make our working levels more than 100 feet apart, (vertical,) or about 140 feet on slope of lode. Another objection is the additional labor of climbing and upraising of tools and timbers.

The cost of sinking shafts varies under so many different circumstances that I can only give practical results that I can obtain from present and former work. A shaft 7 by 18 feet outside of timbers, or full size, can be sunk for $17 64 per running foot, or 14 cents per cubic foot of earth removed. This is in blasting ground, and includes labor of timbering.

Yellow Jacket shaft, between 1,000-and 1,100-foot levels, 8 by 24 feet, full size, was sunk for $27 per running foot, or about 14 cents per cubic foot, all blasting ground. Temperature of air 93°, labor of timbering included.

Incline below 1,100-foot level, full size, 9 by 14 feet, an angle of 45°, all blasting ground, sunk for $20 per running foot, or 15½ cents per cubic foot. Average 3½ feet per day; four shifts of six hours each, four men each.

The cost of timbering such ground as the above, that is, cost of timber and framing the same, will be about 3 feet of timber (lumber or board measure) for each cubic foot of earth removed, or say 10 cents per cubic foot of shaft. Heavy clay or swelling ground will require twice the same.

The cost of drifting, like cost of sinking shafts, depends on character of ground and temperature of air. Have run drifts in hard blasting ground, (cool air, size full,) 6 by 9, for $7 per running foot, or 13 cents per cubic foot of earth removed. Same ground, with temperature of air 107°, cost $30 per running foot, or 55½ cents per cubic foot, cost of labor of timbering included in the above. With cool air made 3½ feet per day; with air at 107°, 20 feet per month.

Cost of timber for drift above size (6 by 9 feet) will be $3 42 per running foot, or 6½ cents per cubic foot. Have run drifts the above dimensions, good working ground, and timber the same, 10 feet per twenty-four hours.

The cost of raising ore, waste, &c., the past ten days, from 1,130-foot level to the surface, (3,025 tons,) was 37½ cents per ton of 2,000 pounds. Estimate that we can raise ore, &c., from 2,000-foot level for 64 cents per ton. The above includes all cost of engineers, brakemen, firemen, fuel, water, oils, &c., but not wear and tear. Can raise or lower men to 2,000-foot level, in four minutes, for 6 cents per man.

The cost of pumping the past year at Yellow Jacket mine has been very small. Have not run pumps for sixty days at a time. Water of whole mine has not exceeded 1 inch (miner's measure, 6-inch pressure) the whole year.

The water in the mine has decreased from 20 inches, at 250-foot level, to less than 1 inch, 1,130-foot level; (miner's measure, 6-inch pressure.)

The cost of milling at present is $12 per ton. Cost of transportation to river mills is about $2 50 per ton; to steam mills within county lines, about 60 cents per ton. Cost of transportation, included in cost of milling ore, $12.

Cost of running two of Root's patent blowers, No. 3 and No. 5, is about $12 per day. Carry air to four different points; nearest 1,300 feet from blower; most distant 2,200 feet. I am unable to state how long a time it will take to exhaust all profitable ore above 600-foot level, or between 600 and 1,000 foot levels. I am ignorant of the quantity in place.

The present machinery in use at the mine, with addition of necessary pumps, ropes, &c., will be available for hoisting and pumping to a depth of 2,500 feet from surface.

The width of the lode at the various levels has never been definitely determined. Have made a cross-section of over 400 feet on 1,000-foot level without finding either side or wall. Productive vein-matter has varied from 12 inches to 24 feet in width.

The cost of prospecting the mine the past year has been abont 30 per cent. of the whole expense of mine for labor and cost of materials, or say $172,000.

Pay-ore has been very regular from surface to 1,100-foot level.

You will please excuse my tardiness in replying to your various questions. Absence and want of time are my only excuse.

Yours, respectfully,

THOMAS G. TAYLOR, *Superintendent.*

Brevet Major General H. G. WRIGHT,
Sutro Tunnel Commissioner.

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APPENDIX J.

OFFICE OF STATE SURVEYOR GENERAL AND LAND REGISTER,
Carson City, Nevada, November 8, 1871.

SIR: In reply to your inquiries, hereinafter given, and numbered from 1 to 7, I have to make the following report:

"1st. The fall of Carson River from the Mexican Dam to the best location for a large dam above and nearest to Dayton. (This is probably at the point where the Franklin Mill-dam now is.")

The fall is 155 feet from Mexican Dam to the Franklin Dam.

"2d. The fall of Carson River from the point selected for a large dam to a point opposite the Sutro Tunnel."

The point selected is the Franklin Dam. Fall of river from this point to a point opposite Sutro Tunnel is 100 feet.

"3d. The height of high water in the river when highest and when lowest; also the height in each month of the year, if possible to be ascertained, and the rapidity of flow at these different times."

The average flow, taking one year with another, is as follows, estimated in square-feet section, with a velocity of four miles per hour: In the month of May, 600 square feet; in June, 700; in July, 700; in August, 600; in September, 500; in October, 500; in November, 400; in December, 400; in January, 400; in February, 400; in March, 400; and in April, 500. This gives an average monthly section of 508.33 square feet, with the velocity as above given. The perpendicular rise and fall of the river per month cannot be given, but the extremes of highest water in floods and lowest water in drought are from 8 to 10 feet in the average width of the channel.

I would state that the amount of water flowing in the Carson River this year is extremely small—far less than ever known since the settlement of the State; and it is not probable that a similar reduction will happen in many years. I have, therefore, based no estimate or calculation upon this year. For the months of August, September, and October, and up to the present time, the flow has been only 25 cubic feet on a grade of 10 feet to the mile.

"4th. The cross-section of the river, at the best point for a large dam, to be sufficiently large and high to hold all the water to the level of the Mexican Dam."

This cross-section is selected as the Franklin Dam, and is shown on accompanying diagram.

"5th. Approximate area in square miles of the reservoir or lake thus created."

Exclusive of any overflow at the town of Empire, a tract 15 chains wide, and eleven and three-quarters miles long from Mexican Dam to the proposed large dam, the surface of water thus created would be 1,410 acres, or two and one-fifth square miles.

"6th. Estimated dimensions and cost of dam to answer the above purpose."

This dam should be 837 feet long and 155 feet high, (see accompanying diagram,) and would cost not less than $200,000. But by moving the site one mile up the river from the Franklin Dam, the dimensions and expense would be greatly reduced.

"7th. Length of canal from location of dam to the mouth of the tunnel, including its windings in following the horizontal curve; also, size of canal in order to carry off the average and accumulated flow of water; also, estimated cost of construction of canal."

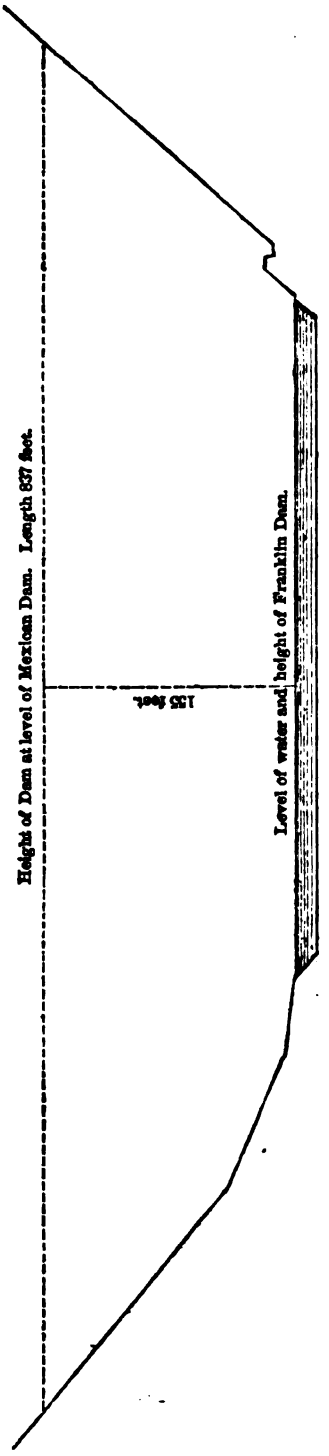
The length of canal would be five and one-half miles. The size of canal would be a cross-section of 600 square feet. The cost of construction of canal, taking a mean average between excavating and fluming, would be $250,000.

With the exception of the fall of river and distances herein given, the estimates could only be approximated; want of time has prevented my making a careful and accurate estimate.

JOHN DAY,
Surveyor General State of Nevada.

ADOLPH SUTRO, Esq.,
San Francisco, California.

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SECTION OF CARSON RIVER AT PROPOSED SITE OF DAM 100 YARDS ABOVE FRANKLIN DAM.

SCALE: 116 ft. = 1 inch.

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APPENDIX K.

[2,185 feet of tunnel, (including open cut;) cost, $42,800 78; commencing October 20, 1869; ending July 1, 1871.]

Character of ground developed.	Respective distance.	Average cost of sup't, foreman, and labor per foot.	Total cost for superintendent, foreman, and labor.	Average cost for frame-timber per foot.	Total cost for frame-timber.	Average cost of iron, steel, tools, oils, and candles per foot.	Total cost of iron, steel, oil, tools, and candles.	Average cost of track-timber per foot.	Total cost of track-timber.	Average cost of track-iron per foot.	Total cost of track-iron.	Average cost of wood per foot.	Total cost of wood.	Average cost of charcoal per foot.	Total cost of charcoal.	Average cost of powder, fuse, and caps per foot.	Total cost of powder, &c.	Average cost per foot.	Total cost for completing 2,185 feet of tunnel.	Total number of days worked by miners alone.	Total length of calendar time.	Average feet of tunnel each day.
								Cts.		Cts.		Cts.		Cts.		Cts.						
Trachytic conglomerate	750	$14 10	$10,574 00	.....	.....	$1 00 +	.....	$737 +	117 87	$134 +	22 31	$177 +	22 31	.....	.....	.....	.....	.....	$11,775 —	1,225	109	7 —
Trachyte	500	16 87	8,435 00	.....	.....	1 00 +	.....	504 +	17 87	89 +	22 31	111 +	22 31	.....	.....	.....	.....	.....	9,413 30	1,140	104	5 —
Trap dike	40	12 81	513 60	$1 48	$59 20	1 00 +	.....	40 48	17 87	7 15	22 31	8 92	22 31	$28 84	11 15	3	$1 90	18 82 +	664 —	138	10	4
Red clay	70	16 55	1,158 50	1 48	103 60	1 00 +	.....	70 65	17 87	12 50	22 31	15 61	22 31	50 48	11 15	3	2 10	16 60	1,421 70	112	14	5
Blue clay	100	18 36	1,835 00	1 48	148 00	1 00 +	.....	100 94	17 87	17 87	22 31	22 31	22 31	72 11	11 15	3	3 00	22 12 +	2,212 25	206	28	3 6
Porphyry, timbered	342	18 44	6,306 48	1 48	506 16	1 00 +	.....	345 25	17 87	61 12	22 31	76 30	22 31	246 63	20	68	40 50	23 76	7,783 92	764	138	2 5
Porphyry, hard	385	19 05	7,296 15	.....	.....	1 00 +	.....	386 30	17 87	66 52	22 31	85 45	22 31	276 18	20	76	63 30	23 02	8,431 17	773	143	2 7
Extra, for open cut	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,099 44	.....	.....	.....
Total	2,185	.....	36,118 73	.....	816 96	.....	2,204 62	.....	380 16	.....	496 59	.....	674 24	.....	343 41	.....	657 24	.....	42,800 78	4,448	546	4+.15

Respectfully,

J. C. HAZLETT.

The Honorable THE SUTRO TUNNEL COMMISSION.

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APPENDIX L.

The following estimate is based upon four miles or 21,120 running feet of the Sutro Tunnel complete:

The large timbers are 12 inches square, and are set 5 feet apart from center to center.

The lagging are 3 inches thick, 6 inches wide, and 5 feet long, containing lumber as follows, to wit:

	Feet
4,225 bents, containing 840 feet each	3,549,000
4,225 bents lagged, containing 570 feet each	2,407,250
8,450 supports for track, containing 36 feet each	304,200
84,480 lineal feet, or 16 miles, track timber, 6 by 6	253,440
Total feet	6,514,890
At $40 per M	$260,595 60
4,225 bents properly in place, at $25 each	105,625 00
Total cost	366,220 60
Cost per linear foot	$17,33 +

Respectfully,

J. C. HAZLETT.

The Hon. THE SUTRO TUNNEL COMMISSIONERS.

APPENDIX M.

SAN FRANCISCO, CALIFORNIA, *November* 23, 1871.

MY DEAR SIR: It was my intention to avail myself of the opportunity to present some additional statements in regard to the Sutro Tunnel, but my time has been so very much occupied since my return to California that it has been almost impossible for me to find the necessary leisure.

I think now that I shall have to reply to the statements of some of the superintendents of the mines on the Comstock lode after your report is published, so I may ascertain what position they take; my reply, of course, can then form no part of your report.

You are, no doubt, well aware of the continued and persistent prevarications of the men who oppose the great work in which I am engaged; and since I have given a complete history of the tunnel enterprise and the motives for that opposition in a speech delivered by me at Virginia City, Nevada, some time ago, I inclose a copy of the same, and would respectfully ask to have the same embodied in the appendix to your report.

That a work of the magnitude of the Sutro Tunnel, which will radically change the mode of working the mines, should find much local opposition, cannot be wondered at. It is the old fight of stage-coaches against railroads, and such fights will always take place as long as improvements are contemplated.

I forwarded to you some days ago estimates of the cost of large dam across Cañon River, with other statistical information about the water-power on the river, which I hope has duly reached you.

I am, dear sir, your most obedient servant,

ADOLPH SUTRO.

Major General H. G. WRIGHT,
Senior Officer Sutro Tunnel Commissioners.

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APPENDIX FF.

LETTER OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, RELATIVE TO CERTAIN OMISSIONS IN REPORTS AND MAPS OF EXPLORATIONS.

UNITED STATES ENGINEER OFFICE,
Mobile, Alabama, April 23, 1872.

GENERAL: Looking over the report just received of Mr. Clarence King, United States geologist, of his exploration of the fortieth parallel, volume v, Botany, submitted to the Chief of Engineers, and published by order of the Secretary of War, under authority of Congress, I notice that he ignores the fact of the Overland Stage-Road over the Great Basin of Utah having been first opened under the Bureau of Topographical Engineers by me, while chief engineer of the army of Utah in 1859. I also notice that, under the head of the *Cactacea*, by Doctor George Engleman, allusion is frequently made to the collections by his brother, H. Engleman, one of my assistants in that expedition, but not a remark as to my having had charge of the same, which I notice has not been the case with regard to the botanical discoveries made in other expeditions under other officers. I do not know that this was intentional, but the route explored and first opened by General Marcy and myself in 1849 along the South Fork of the Canadian between Fort Smith and the Rio Grande, reports and maps of which were made by each of us and published by Congress, having been in a like manner ignored, I confess that I have felt hurt by these omissions, and think it due to myself and history that I should thus officially refer to them. Both of these routes were *original* routes, and as, in the case of the Canadian route in 1853, the officer of Topographical Engineers in charge—as I was informed by Captain Jones, Seventh Infantry, who commanded his escort—made daily use of my reports and maps and actually traveled over the identical track we had provided for him, I have always thought that great injustice was done by him in thus totally ignoring in his report and maps all that Marcy and myself had done before him.

So in the case of the route over the Great Basin of Utah. Not a white man had traveled over it before my party did, and as I shortened Frémont's route between Great Salt Lake City and Carson City over two hundred miles, which others had attempted to do and failed, and I look upon it as the greatest feat, under Providence, of my life, I trust you will not regard me as being over-sensitive in what I conceive as an unjust imputation of my services and a disregard to the credit which should be accorded to an officer of the corps in his labors.

For a time my route over the Great Basin of Utah was laid down on the Bureau's map of the territory of the United States, and among the "authorities" given my name was omitted till I drew the attention of the Department to it, when the proper correction was made, *except that the date is still omitted.* It is true that my longitude of Salt Lake City differed so widely from all others (as much, I think, as twelve miles) as, I was informed, to cause this omission; but it seems to me that due credit might have been given me for the route, and the discrepancy referred to have been mentioned in a note. I was, however, made glad by the receipt of a letter from the Bureau when I was stationed in Baltimore, (1868–'70, precise date not recollected,) informing me that the Coast Survey, after the most elaborate observations, had found my longitude of Salt Lake City correct, and all others wrong.

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I repeat that it is mortifying to be obliged to refer to the above instances of omission of proper credit, but history and facts fully bear me out in all I have stated. I have always taken special pains in all my reports and publications to observe the golden rule, of doing to others as I would they should do to me, and I do not know that a single instance can be pointed out wherein I have claimed or assumed for myself what was due to another.

I am, very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

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Errata.—Page 83, three lines from bottom, for 52 read 521.

Page 428, next line to bottom, for 18.13 read 19.17.

The figure on page 1089 should have been placed on 1090, to follow the words "to keep the rod in place."

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